The N. C. Agricultural Experiment Station

1902—1903

TWENTY-SIXTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

Year Ending June 30, 1903.

INCLUDING

TECHNICAL AND SCIENTIFIC PAPERS, AND BULLETINS
Nos. 182, 183, 184, 185.

Raleigh, North Carolina.

RALEIGH:
PRESSES OF EDWARDS & BROUGHTON.
1904.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. AND M. COLLEGE.

S. L. PATTERSON, *ex officio* Chairman, Raleigh.

J. M. FOREHAND.....Rockyhock	A. T. MCCALLUM .....Red Springs
J. B. STOKES .....Windsor	J. P. MCRAE .....Laurinburg
WM. DUNN.....New Bern	R. L. DOUGHTON.....Laurel Springs
C. N. ALLEN.....Auburn	W. A. GRAHAM .....Machpelah
R W. SCOTT.....Melville	A. CANNON.....Horse Shoe

GEO. T. WINSTON, L.L. D., President of the College.

STATION STAFF.

B. W. KILGORE.....Director.
W. A. WITHERS .....Chemist.
W. F. MASSEY.....Horticulturist.
C. W. BURKETT.....Agriculturist.
TAIT BUTLER .....Veterinarian.
F. L. STEVENS.....Biologist.
FRANKLIN SHERMAN, Jr.....Entomologist.
G. S. FRAPS.....Assistant Chemist.
J. S. JEFFREY ..... Poultryman.
B. F. WALTON.....Assistant in Field Experiments.
J. C. KENDALL.....Assistant Dairy Husbandry.
B. S. SKINNER .....Farm Superintendent.
A. F. BOWEN .....Bursar.

The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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LETTER OF TRANSMITTAL.

Raleigh, N. C., June 30, 1903.

To His Excellency, Charles B. Aycock,
Governor of North Carolina.

Sir:—I have the honor to transmit herewith the report of the operations of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year beginning July 1, 1902, and ending June 30, 1903.

Very respectfully,

S. L. Patterson,
Chairman Board of Trustees.

LETTER OF SUBMITTAL.

The North Carolina
Agricultural Experiment Station,
Office of the Director,
Raleigh, N. C., June 30, 1903.

Hon. S. L. Patterson, *Chairman Board of Trustees.*

Sir:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year ending June 30, 1903.

Trusting that this report will prove satisfactory, I am,

Very respectfully,

B. W. Kilgore,
Director.

TWENTY-SIXTH ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

For the Year Ending June 30th, 1903

By the Director.

This report covers the work of the Experiment Station from July 1, 1902, to June 30, 1903.

CHANGES IN STATION STAFF.

During this time Dr. F. L. Stevens, who had been connected with the Agricultural College for some time, was made Biologist of the Station; Mr. Franklin Sherman, Jr., who has been for several years and is now engaged in entomological work for the State Department of Agriculture, was made Entomologist; and Mr. J. S. Jeffrey, of St. Catharines, Canada, and formerly a student in the Ontario Agricultural College, at Guelph, took up the poultry work after the resignation of Mr. H. P. Richardson.

WORK IN THE AGRICULTURAL DEPARTMENT.

The fertilizer, culture, and variety tests with cotton and corn, described in detail in the previous report, have been continued with the view of collecting a number of years' results before publication.

In like manner the experiments with grasses and legumes for pasture and hay are still in progress, and other work has been added along the lines indicated in the report of the Agriculturist.

WORK IN THE CHEMICAL DIVISION.

The investigations the past year have been principally in continuation of experiments already begun and relating mainly to the study of the rate at which various nitrogenous fertilizer materials nitrify and become available for plant food and the effect of different soils in bringing this about. The assimilation of free nitrogen from the air is one of the most important questions in agriculture. Conditions most favorable for the development in the soil of organisms which enable plants to get this nitrogen from the air have been studied. Other work has also been done on the sulphur content of plants along the line indicated in last year's report.

Papers of a more or less technical nature, giving the results of chemical work, are included in this report, as follows:

I. Nitrification of Different Fertilizers.
II. Studies in Nitrification.
III. Nitrification of Ammonia Fixed by Chabazite.
IV. Nitrifying Power of Typical North Carolina Soils.
V. Assimilation of Free Nitrogen by Bacteria.
VI. Determination of Sulphur in Plants.

WORK IN THE HORTICULTURAL DIVISION.

For the reasons given in the present and previous reports of the Horticulturist, the work in this line has been reduced considerably. The experiments in progress with strawberries and vegetable crops, which required one year for completion, have been finished and the results will be presented in bulletin form.

Tests of varieties of grapes, apples, peaches, pears and plums are being continued.

The horticultural grounds have been given up mainly to the Poultry Division, though this change has not been allowed to interfere with work which was in progress in horticultural lines, and which it seemed desirable to continue.

A considerable amount of the Horticulturist's time is taken up in correspondence with farmers of the State and in the conduct of Farmers' Institute work when called on by the Department of Agriculture.

WORK IN THE BIOLOGICAL DIVISION.

The Biologist presents in considerable detail in his report the diseases which are affecting the fruits and other crops of the State. A number of Bulletins have been prepared, in joint authorship with the Entomologist, describing these diseases and the insect enemies of the several crops, and suggesting remedies for them. A preliminary piece of work in the line of investigation was taken up in Granville County in the study of tobacco wilt. This disease has given a great deal of trouble in certain portions of the old bright tobacco belt, making it very uncertain in growing this crop where the disease appears. A special Bulletin on the subject has been issued, and experiments have been planned on a reasonable scale for obtaining more definite facts relating to the disease, as well as to the discovery, if possible, of means of preventing it.

Watermelon wilt, a similar disease to that of tobacco, and affecting this crop in a number of parts of the State, has been dealt with in a similar way, and we hope for results which will give help to our growers of these crops.

There are a number of important lines of work in this field of the Station's endeavor, which will receive all the attention which the time of the Biologist can give to them.

WORK IN THE POULTRY DIVISION.

Mr. J. S. Jeffrey assumed charge of the poultry work in February. The old quarters were too cramped to allow for the expansion which was desired for poultry work. The first efforts of the Poultryman were therefore devoted to the removal of the poultry and equipment to the horticultural grounds, which it had been decided should be given up, in the main, to the poultry work. Suitable houses and runs have been erected, together with a building with basement for incubators, office, work and other rooms for the poultryman. A considerable amount of new stock has been added and some experimental work undertaken. A great many inquiries come to the Station for methods of preserving eggs during the spring and summer months, which has caused the beginning of quite a number of tests to determine, if possible, successful methods for egg preservation. There is a growing interest in poultry in the State, and with a well-equipped poultry plant, which we should have reasonably soon, important aid can be given to the development of this industry.

ENTOMOLOGICAL DIVISION.

The expenses of the entomological work is met by the Department of Agriculture. As will be seen by Mr. Sherman's report, a large amount of most valuable and telling work is being done in this line in aiding the farmers of the State. This season some experimental work is being done in which the Station is paying for the actual cost of materials and extra labor.

FARMERS' INSTITUTES.

The Station has aided the Commissioner of Agriculture in conducting Farmers' Institutes by sending members of the staff whenever called on by him for this. We consider this a most important phase of agricultural work,—one that should be encouraged and extended in every way possible.

PUBLICATIONS.

In last year's report a number of technical papers from the Chemical Division were published instead of making of them special Bulletins. This plan is followed again this year, and a number of reports of work in chemical lines are presented. In addition to these, Bulletins have been issued as follows:

No. 182—The Apple, by W. F. Massey, T. K. Bruner and Gerald McCarthy.

No. 183—Insect and Fungus Enemies of the Apple, Pear and Quince, by Franklin Sherman, Jr., and F. L. Stevens.

No. 184—The Culture and Marketing of Orchard and Garden Fruits, by W. F. Massey.

No. 185—The Black Rot of the Grape in North Carolina and Its Treatment, by A. W. Edson.

And Press Bulletins as follows:

No. 4—Treatment of Oats for Smut.
No. 5—Weevil in Grain.
No. 6—Weevil in Grain.
No. 7—Silk Culture.
No. 8—Scab of Irish Potato.
No. 9—Black Rot of Grape.

The Press Bulletins are short, concise statements of matters of immediate interest and benefit to our farmers, and are issued whenever material is available and it seems desirable.

CORRESPONDENCE AND CONCLUSION.

The number of letters of inquiry which come to the Station covering the different phases of farm operations are on the increase, and show that our farmers are interested in the Station and its work, and are looking to it for assistance in their farming matters.

It is our hope and purpose to make the Station more useful to the farmers each year.

REPORTS OF HEADS OF DIVISIONS AND FINANCIAL STATEMENT.

The reports of the heads of the several divisions of the Station's work and financial statement follow:

REPORT OF THE AGRICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—During the past year the Station work in this division has been centered along the the same lines as outlined in last year's report. The experiments are planned to extend through a series of years, with the idea of obtaining information of practical as well as fundamental bearing.

Additional work has been taken up with tobacco, soja beans and alfalfa.

Considerable land has also been cleared the past year, thus enlarging the area devoted to Station work and now making it sufficient for the needs of the division.

AGRONOMY AND PLANT PRODUCTION.

Several hundred plats are now being used for investigation in agronomy and plant production in the following lines of work:

1. *Grasses and Forage Crops—*

Many of the principal grasses and forage crops have been tested. The vetches, clovers, cow-peas, soja beans, corn, and Bermuda have all done splendidly, and suggest good possibilities for the live-stock husbandry for the State.

2. *Cow-Peas—*

These have been tested in reference to time of planting, quantity of seed, methods of planting, varieties and fertilization. Cow-peas are also being studied in their relation to soil improvement.

3. *Wheat—*

Wheat culture in relation to cow-peas, varieties of wheat, and time of planting are involved in the present tests. The division is planning to include experiments with fertilizers in the near future.

4. *Corn—*

The experiments with this crop are reasonably extensive in nature to cover the important factors incident to corn culture. The tests include the fertilization of corn, rotation of crops in reference to corn growing, time of planting, variety tests, quantity of seed and distance in planting.

5. *Soja Beans—*

Experiments with soja beans include fertilizer tests, varieties, quantity of seed, methods of planting, effect of liming, etc. This work was begun this year.

6. *Cotton*—

Tests along the same line as corn are being conducted with cotton.

7. *Alfalfa*—

Work with this crop consists of testing spring and fall seeding, and includes fertilizer tests, value and effect of inoculation, effect of liming, etc.

SOIL IMPROVEMENT.

About one hundred and fifty acres of old worn-out land have been taken up, the scrub pines and oaks cut, and fields plowed and kept under a constant rotation. The problem of such lands is receiving a good deal of attention by the division, and interesting results are at hand.

FEEDING FARM HORSES AND MULES.

This work includes numerous comparisons with feeding stuffs, both roughage and concentrates. Weekly weighing of all animals used in the experiments give reliable data for conclusions.

THE DAIRY INDUSTRY.

Since a good part of the manufactured dairy products used in the State is brought from other States, it follows that the dairy industry is one of great and growing importance. This is doubly so on account of the marvellous development of manufacturing interests in the State. The division is giving careful attention to dairy education, the improvement of dairy stock, and the production of milk and butter. The whole College herd of fifty cows is used in this investigation. The lines being considered are: The cost of producing milk and butter with Southern feeds and under Southern conditions; the milk and butter capacity of dairy cows; comparison of feeding stuffs raised in the State, methods and practice in farm dairying, etc.

A careful record of each cow is being kept. The milk of every cow at every milking is recorded and sampled for determination of butter contents. Other phases of dairying are also being studied.

CONCLUSION.

I desire to express my high appreciation of the work of Mr. J. C. Kendall, assistant in dairying, and Mr. B. F. Walton, assistant in agronomy and field work.

Respectfully submitted,

CHARLES WM. BURKETT,
Agriculturist.

REPORT OF THE CHEMICAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—With a favorable climate and favorable seasons, the crop-producing power of a soil is dependent to a very large extent upon the amount of available plant food with which the rootlets of the growing plant come in contact. This available plant food must have been added to the soil in an available form, or been rendered available by the breaking down of the soil. In many of the older States the food is furnished to the plants from both these sources. One of the principal objects of cultivation is to afford a more favorable condition for disintegration of the soil, and in consequence a liberation of plant food. One of the elements which is indispensable to plant growth and which is needed in large quantities is available nitrogen. In the soil it exists in the form of nitrates, nitrites, ammonium salts, and in many organic forms, which differ greatly in availability to plants and therefore in value. Nitrates are liable to be lost by leaching, and under some conditions the nitrogen may be changed to the free state and escape in that form. Nitrogen exists in the greatest variety of forms of all the elements needed by plants; it is the most liable to be lost and is withal the most expensive element which the farmer purchases for fertilizing purposes.

Any study which will aid in securing for the plant a larger proportion of nitrogen from the vast stores of this element in the air, which will render the supply of it in the soil more readily available, or which will prevent the loss of that which exists in the soil in a readily available form, will greatly increase the profits of farming. It is generally accepted as a fact that these changes are to a very great extent brought about by the action of various minute organisms. During the year this division has continued the study of one of these changes, viz., nitrification, and has begun the study of another, viz., the assimilation of free nitrogen. Studies have been begun as to the availability of potash and phosphoric acid which are of great consequence in plant production.

STUDIES IN NITRIFICATION.

The division has previously called attention to the facts (1) that some soils nitrify ammonium sulphate more rapidly than cotton-seed meal, while in other soils the reverse is true, and (2) that nitrification may be accelerated by the addition of calcium carbonate; and has offered as an explanation (*a*) that the nitrifying materials may be more or less harmful to bacteria of themselves or on account of substances formed from them, (*b*) that soils differ in respect to the

organisms which they contain, and (*c*) that it is quite probable that there is a germ which is capable of changing nitrogenous organic compounds directly to nitrates or nitrites,—such a germ not having been isolated or its existence suggested hitherto.

During the present year the work was continued along the following lines:

Nitrification in Different Soils.—Four soils of different characters were selected from the College farm, and treated with various nitrogenous materials according to methods described in previous reports. The nitrification in the different soils after four weeks differed very much, being greatest in the rich clay and the pasture soils, less in the rich sand and poor clay, and least in the poor sand.

Nitrification of Different Materials.—In different soils experiments were made with the following materials: tankage, dried blood, fish, bone, cotton-seed meal, bat guano, and stable manure; gelatin, casein, and albumen; ammonium sulphate, ammonium chloride, ammonium citrate, and ammonia fixed by chabazite. Calcium carbonate was not added. There was a wide variation in the amounts of nitrates formed from these different materials during the same period of time. Casein was nitrified less rapidly than the other proteids, ammonium sulphate was nitrified more rapidly than the other ammonium salts except the ammoniated chabazite, which was nitrified more rapidly than any other nitrogenous substance used. There was considerable variation with the other materials, there being instances in which cotton-seed meal, dried blood, and fish each stood at the head of the list, but the average was the highest for fish.

Bone was nitrified to only a slight extent, and in all cases but one, there was less nitrification in the soils to which stable manure had been added than in the soils without the addition of any nitrogenous fertilizer. In the case of stable manure, the explanation is that on account of the small percentage of nitrogen, there was a great amount of organic matter which exerted a reducing effect. In actual field work where a smaller amount of stable manure would be added, the reduction would not be so great. That stable manure will cause a reduction of nitrates is a fact of importance in agriculture. In the case of bone the explanation is that bone is the most resistant part of the animal body, and naturally it nitrifies slowly in the soil.

Difference in the Organisms.—In the same soil there is a difference in the number and activity of the organisms, if the samples are taken at different times; the activity of organisms in the same soil and under the same conditions is periodic, nitrates being formed much more rapidly during some periods than others; it is possible by cultivation to change the relation between the nitrates produced from cotton-seed meal, and from ammonium sulphate; when there is a large amount of organic matter present, or if the amount of air is limited,

oxidation of the carbon and hydrogen takes place, but not of nitrogen —and in some instances some of the nitrates already formed were reduced, the oxygen of the nitrates being used to oxidize the carbon and hydrogen.

Another Nitrifying Organism.—It has been generally supposed that there are three classes of organisms in the soil, viz., those which convert nitrogenous organic matter to ammonium salts, those which convert ammonium salts to nitrites, and those which convert nitrites to nitrates. The facts to which the division has called attention above confirm the previous work of the division, indicating that there is a class of organisms in the soil which is capable of changing nitrogenous organic matter to nitrites or nitrates, and which has not been isolated and described heretofore.

Methods of Comparing Nitrifying Power of Different Soils.—As nitrification depends upon the number and activity of organisms, the food supply, and favorable conditions of temperature, moisture, etc., and as these conditions vary in the soil in the natural condition from day to day, this division has proposed a method for comparing the nitrifying power of different soils under conditions which shall all be uniform.

Nitrification of Typical North Carolina Soils.—With the method referred to this division has made tests showing the relative power of fifteen typical soils to support nitrifying organisms. There was a wide variation in this power in the different soils. The better soils, as a rule, gave greater nitrification, and the poorer soils less nitrification.

Four articles are submitted herewith for publication, embodying the work referred to. They are entitled: "Nitrification of Different Fertilizers," "Studies in Nitrification," "Nitrification of the Ammonia Fixed by Chabazite," and "Nitrifying Power of Typical North Carolina Soils."

Further work is proposed.

THE ASSIMILATION OF FREE NITROGEN.

There is a considerable loss of the stock of combined nitrogen each year, some of it being changed to nitrates and carried to the sea, and some of it being lost as free nitrogen. It is well known that there are bacteria which live on certain plants which can assimilate free nitrogen from the air, and render it available for agriculture. A study of the conditions under which these bacteria live and do their work, and which will lead to improving the conditions at present existing, will be of great benefit to agriculture. The work of the past year has been preliminary, and has consisted largely in the study of the food of these bacteria. It has been found that in the media studied, the nitrogen-assimilating bacteria are most active in an alkaline me-

dium, containing glucose, potassium phosphate, sodium chloride, calcium carbonate, magnesium sulphate, and ferric chloride in certain proportions; that they are less active when magnesium sulphate is omitted, and that they are very much less active in a neutral liquid containing mannite, potassium sulphate, ferric chloride and soil. The nature of the soil used for inoculating has its effect. The effect of time was studied also. A paper entitled "The Assimilation of Free Nitrogen by Bacteria," embodying the results of this work, is submitted herewith for publication.

DETERMINATION OF SULPHATES IN PLANTS.

Some analyses of different parts of various common agricultural plants have been made, with a view to determining the amount of sulphates present. No sulphates were found in corn (grain), peas (grain), green millet, timothy hay, corn silage, peanuts, sorghum and teosinte. Traces of sulphates were found in oats, crimson clover straw, cotton-seed meal, cow-pea vines. A paper embodying the results of this work is submitted herewith for publication.

OTHER WORK.

This division has made several determinations of formaldehyde in solutions and in potatoes for the Biological Division. As Referee of the Association of Official Agricultural Chemists, Dr. Fraps, Assistant Chemist, has conducted some work upon methods of analysis of the ash of plants.

CHANGES IN STAFF.

At the time of writing this report, Dr. Fraps has resigned to accept a position in the Texas Experiment Station. He is an enthusiastic worker, and carries with him the best wishes of this division for success in his new field. Mr. Wm. G. Morrison, a graduate of the University of Virginia, with the degrees of B.A. and M.A., and a former student of the University of Paris, has been appointed his successor.

Very respectfully,

W. A. Withers,
Chemist.

REPORT OF THE HORTICULTURAL DIVISION.

PROF. B. W. KILGORE, *Director.*

SIR:—I herewith submit the report of the Division of Horticulture for the past year.

The fruit trees planted in orchards for variety test and a study of methods have grown well. The peach trees have been bearing for two seasons, though the crop this year was small. On the red clay soil where the peaches are planted I am of the opinion that the fruit will never be a success, though the trees grow well, for there seems to be a failure of the fruit to color well, and one can hardly recognize the varieties for this reason. Last spring it was discovered that these peach trees had been attacked by the San Jose scale insect. The trees were too far advanced in growth for any efficient means to be used this summer. The worst infested trees were destroyed, and it is proposed to adopt active means for their destruction the coming winter. In the meantime it is hoped that the lady birds that have been introduced may multiply to such an extent as to check the ravages of the scale. More recently some have been found on the young apple trees. The plums have grown well and are bearing heavy crops. Those most resistant to rot among the Japanese sorts are the Burbank, Ogon and Satsuma. Red June seldom rots much, but the only tree we had was destroyed in the building of the new poultry houses. A large part of the peach and plum orchards have been enclosed in the poultry yards, and it is hoped that the fowls will be an efficient aid in the extermination of the curculio and other insects. It has been found that the soil at the farm is entirely unsuited to the experimentation with vegetables, and no experiments in this line have been inaugurated. In my own garden I have been carrying on some variety tests of which I hope to give an account in my report the last of the year, and may have a bulletin on the same subject.

The experiments with flowering bulbs are still continued, and I find that with some of them we can produce fine results. The Bermuda lily, which is the most important bulb to the trade, has not as yet been a success. Most of the bulbs were transferred to the eastern part of the State, but as yet no satisfactory results have been had, though the prospect is that they may succeed there. The fact that over a million dollars worth of these bulbs are imported every year from the Bermuda Islands is a strong inducement to endeavor to find out some means for growing them here. Some of the tuberose growers in the eastern part of the State are experimenting with them, and doubtless we will find out the method by which these bulbs can be

produced here on a commercial scale. We can grow and are growing successfully the Gladiolus and various Narcissi. The new Gladiolus known as Groff's Hybrid increases very rapidly here, even the small offsets making flowers the first year. I have saved a quantity of seed this season, and hope to get some good varieties in this way. In the North it takes two seasons to get a blooming corm from the seed, while here I have produced them in one season. From 100 bulbs of this Gladiolus bought two years ago, I now have over three thousand bulbs that will bloom another season, and it is evident that our growers can produce them more profitably than the tuberose. Another advantage the bulb growers in the eastern part of the State have over other sections is that these bulbs produce flowers earlier in the season than northward, and enough cut flowers can be shipped from the open field to pay all the expenses of growing the crop. The same can be done with the Narcissus and the lilies.

As reported heretofore, I have found that in the growing of a winter crop of lettuce, which is becoming one of the most important crops with our truckers, that the best lettuce can be grown only with a combination of stable manure and fertilizers, and that neither fertilizers alone nor manure alone will make the best crop. I have also demonstrated that a fertilizer in which the ammonia is derived from cotton-seed meal is a dangerous fertilizer for lettuce, since the meal seems to promote the growth of a fungus that creeps over the bed and causes the stem rot in the lettuce. This was so completely proven in my experiments last winter that I consider it an important matter to warn growers of lettuce against the use of cotton-seed meal in the beds.

It is hoped that a suitable location can be found ere long for the horticultural work of the station, and I am trying to find such a location.

The chief work in my division this year has been the preparation of the popular bulletins so much called for and needed on fruit culture and truck gardening. I have prepared a bulletin on the Apple, and one on the pear and other orchard fruits, which have been published. I have one ready for the press on Small Fruits and another on Vegetable Culture, and in the near future will have one on Bulbs and Flowering Plants for the information of the eastern growers.

The correspondence that falls to my share with the farmers of the State has been as heavy as ever, and in fact during the present summer has been heavier than usual at that season. I have also lectured at a number of Farmers' Institutes.

Though the farm has been turned over to the care of the Poultryman, I will still give some attention to the orchards, and will assist the Poultryman in any way that I can.

Respectfully submitted,

W. F. Massey,
Horticulturist.

REPORT OF THE BIOLOGICAL DIVISION.

DIRECTOR B. W. KILGORE.

DEAR SIR:—I have the honor herewith to present the report of the Biological Department for the year ending June 30, 1903.

The work of the Biologist may readily be considered under four heads, namely:

(1.) Correspondence.
(2.) Preparation of Bulletins.
(3.) Other dissemination of knowledge.
(4.) Investigation.

(1.) *Correspondence.*—Very numerous inquiries have been presented through letters. These pertain principally to plant disease and its treatment with occasional questions, in the aggregate quite numerous, as to the identity of various weeds and other plants, seeds, etc., with questions as to their utility or harm, and in the case of weeds as to their mode of dispersal or eradication. Letters concerning plant disease, often accompanied by specimens of the disease in question, show the existence of the following plant diseases in the State: On the apple, fire-blight, canker, black rot, ripe rot, scab and rust; cabbage, the brown rot, or yellow sides, and the club root; carnation, the rust; carrots, a root gall caused by nematodes; celery, the leaf blight (*Cercospora*) and the leaf spot (*Septoria*); cherry, the black knot and the fruit mould; chrysanthemum, the rust and the leaf spot (*Septoria*); corn, the rust and smut; cotton, anthracnose, wilt, root rot, and the root gall due to nematodes; grape, the black rot; hollyhock, the rust; oats, smut and rust; peach, crown gall, curl, scab, and fruit mould; pear, anthracnose and fire-blight; plum, fruit mould and plum pockets; quince, fire-blight and rust; raspberry, rust; rose, black spot; sweet potatoes, the soft rot; tobacco, wilt; tomato, blight or wilt, blossom end rot, and the scab; turnip, club root; watermelon, wilt and anthracnose; wheat, rust and smut.

Of the above diseases a few are worthy of especial notice.

The ripe rot of the apple has been exceedingly destructive throughout the State, and letters concerning it have been received from many regions. The recent discovery of the mode of wintering as described in Bulletin 183 may lead to its better control.

The fire-blight has been exceedingly destructive to both apples and pears, and its effects are only too noticeable from the car window as one rides through any portion of the State. Concerted effort among the farmers will lead to the control of this disease.

Many queries have been received concerning the rust of the apple. Attention of all is called to the methods of combatting this disease recommended in Bulletin 183.

A field of carrots located near West Raleigh was found to be seriously affected with root gall. Examination showed this to be due to nematodes. This is apparently a new victim for the nematodes.

The fruit mould on the cherry, plum and peach remains one of the most destructive of plant diseases. There have been queries concerning it from every portion of the State, and in many regions they indicate excessive damage, damage amounting almost to a prohibition of the crop. Treatment of this disease has not yet reached a satisfactory basis. It is the hope of the Station to do further work with the fruit mould during the coming years. Suggestions in accordance with the present knowledge are to be found in Bulletin 183.

Corn smut is everywhere abundant and destructive. It is recommended that every care be used to prevent old smut from remaining on the fields, thus contaminating the ground. All diseased parts should be gathered and burned.

The cotton anthracnose is very widespread and destructive, and deserves investigation. Seed from sick plants are to be avoided.

The cotton wilt that was previously destructive in the more Southern States, is encroaching upon North Carolina. Any farmer who finds the wilt present in neighboring fields should use the most extreme care to prevent its spreading into healthy fields. Some of the precautions are the same as those indicated for the melon wilt, in Press Bulletin 10.

The black rot, probably the most serious grape disease in North Carolina has shown itself amenable to treatment. See Bulletin 185.

The wilt of the melon, similar to that of the cotton, is invading North Carolina from the South. It was noticed this year in an exceedingly destructive form near Garner and Auburn. Reports of it have been received also from Wilson. It is doubtless spreading northward into other portions of the State. Melon growers who now possess healthy soil should heed carefully the suggestions given in Press Bulletin 10, as by proper precaution healthy soil may be kept healthy. Carelessness will surely lead to the further spread of the disease.

The peach curl is a frequent subject of inquiry. Satisfactory treatment will be found in Bulletin 183.

The peach scab is noticed in great abundance on peaches in the market. So bad were the specimens that North Carolina was able to furnish typical scabby peaches for the St. Louis Exposition.

Plum pockets have been frequently reported. They are discussed in Bulletin 185.

Very numerous tobacco diseases have been examined. One of these is discussed below.

The tomato suffers excessively in many portions of the State from a soil infection known as the wilt or blight (Bacillus). The blossom

end rot is also exceedingly destructive, while the scab (*Cladosporium*) is destructive in greenhouses.

Rust on all cereals was unusually destructive this year. This, combined with the effects of the Hessian fly, in many cases completely destroyed the cereal crop.

(2.) *Preparation of Bulletins.*—During the year press bulletins upon the following timely subjects were issued:

Press Bulletin No. 4, October 28, on the treatment of oats, wheat, rye and barley for smut.

Press Bulletin No. 10, August 8, 1903, on the watermelon wilt.

Press Bulletin No. 11, August 22, 1903, on a dangerous tobacco disease.

Bulletin No. 185 was issued by the Biologist and Entomologist, treating of the fungus and insect enemies of the apple, pear and quince. Another similar bulletin, now in the hands of the printer, treats of the insect and fungus enemies of the peach, plum and cherry, while another bulletin, also still in the hands of the printer, treats of the general subject of spraying.

(3.) *Other Dissemination of Knowledge.*

Many modern discoveries which might lighten the labors and increase the profits of the farmer are yet of little avail to the general agricultural community, owing to the fact that the farmers as a class are not in possession of many of the important scientific advances pertaining to their work. One important duty of the Experiment Station, therefore, becomes the dissemination of knowledge. A case in point is that of oat smut, which injures the State annually to the extent of about $247,000.00, all of which loss is readily preventable at a cost of about four cents per acre.

To bring the means of prevention clearly and forcefully before the farmers, who often are not impelled to action by merely reading printed bulletins, a series of co-operative experiments was undertaken. The Station has provided the material and explicit printed directions for treatment, and asked the farmers to make the treatment and to report upon it, giving an accurate estimate as to the cost of the treatment and the benefits derived therefrom. Owing to the extremely unfortunate season the crop, treated or untreated, in many cases was so poor that it was not harvested. These experiments will be conducted through another year. The co-operation of the country schools is desired, and the teachers and county superintendents have been invited to make the experiments in connection with their school work as an object-lesson for the farmers of their community. The results of this co-operative test will be published in bulletin form upon its completion.

The Biologist has very frequently talked upon subjects of agricultural interest at farmers' institutes, teachers' institutes, and other

public farmers' gatherings. The biological work of the College also supplements admirably the work of the Experiment Station, inasmuch as it gives a selected class of more efficient young farmers in whom the modern advances of agriculture find ready adherents. So, too, the Summer School at the A. and M. College brought the Experiment Station workers in close contact with the country school teachers, thus presenting a very broad field for the work, a method which in many cases is vastly superior to the printed page.

(4.) *Investigation.*

The work of the Biologist in investigation is limited by both time and equipment. Many serious plant diseases, as has been shown above, abound in the State. Some of these are little known, and methods of treatment are practically unknown. Many of them would doubtless give way before a searching investigation. The fruit mould and the cotton anthracnose and the tomato rots are promising subjects for study in the future.

The principal work of investigation during the past year has been in connection with two violent outbreaks of disease, namely, the watermelon wilt, previously mentioned, and a tobacco wilt which has been destructive in Granville County. Methods of treatment of the melon wilt have been suggested in Press Bulletin No. 10. The tobacco wilt is apparently new to literature. Its nature and the method of treatment are at present under investigation in the Experiment Station.

Other work pertaining to plant diseases and plant breeding is also in progress or under consideration, but is in such condition that further mention at present is not advisable.

Respectfully submitted,

F. L. Stevens,
Biologist.

REPORT OF POULTRY DIVISION.

PROF. B. W. KILGORE, *Director.*

DEAR SIR:—I beg to submit the following report of the work in the Poultry Division from February 1 (the time when I took charge of the work) to June 30:

There having been no Poultryman in charge for some time, I found no experimental work under way and the condition of the stock was such that I felt that any experimental work with them would not be satisfactory, and the work has therefore been mainly of a preparatory character.

The erection of new buildings and the removal of the old plant has taken a large part of my time, but with the improved condition I will be in a position to carry on more satisfactorily the experimental work which I have planned for the coming fall and winter.

I am at present carrying on some experiments with egg preservatives, the results of which I expect will be ready in January next.

I also intend to do some experimental feeding both for egg production and meat. In the former I will try the relative values of milk, meat, meal and green cut bone as the source of animal matter in the ration, and in the latter different combinations of ground grains will be tried both as to cost of production and quality of meat, also crate feeding against pen feeding for cost of production and quality.

I will also try what can be done in this climate in raising winter chicks of the heavier breeds to sell as roasters in the Northern markets in May, June and July, when prices rule from 25 to 35 cents per lb. I think we should be able to more than hold our own with the Northern growers for this market, as our climate should more than compensate for the heavier express rates.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

REPORT OF THE ENTOMOLOGIST.

PROF. B. W. KILGORE, *Director.*

SIR:—The Entomologist of the Experiment Station is also Entomologist of the Agricultural Department, all work under both institutions being conducted from the same office, with same equipment, and by same person. It is, consequently, impracticable to distinctly separate the one from the other.

The principal task which the Entomologist has to deal with continually, is the inspection of orchards and nurseries for the San Jose scale. The nursery inspection for 1902 was begun July 23 and completed about November 1, some minor details being completed after that time. Throughout the entire season of nursery inspection, and for a few weeks preceding its opening, all other field work has to be entirely neglected, as the inspection of the forty-six nurseries absorbs the entire time that can be devoted to field work through the summer. Even the correspondence is attended to only with the greatest difficulty. This work, therefore, stands as an effective barrier against carrying on any investigations into life-histories or remedies for such insects as need attention during the summer months.

In winter, the work of inspecting commercial and home orchards which are infested with San Jose scale, together with correspondence relating thereto, takes up the greater part of the time. From June 1, 1902, until the present time (May, 1903), the San Jose scale has been determined to exist in no less than twenty-four localities where its presence was not before known. In many of these the pest had been present for several years, though the fact had not been known to us. It is gratifying to know that in the majority of cases the owners of infested trees are treating them by approved methods or removing them so that they shall not be a menace to other orchards in the community.

Outside of the inspection work, the efforts of the office have been principally to induce farmers and fruit growers to adopt the most approved methods of combatting insect pests. The advantages of spraying have been continually held up to them, and thus far every thorough test among the farmers has only added testimony to the value of the operation. A goodly number of letters might be quoted to show the gratification of farmers at our work along this line.

The general correspondence of the office has been quite heavy. It must be remembered that the nursery inspection work and matters pertaining to executive management of the work comprise a large part of the office work, yet throughout the season when crops are growing we have upon several occasions received inquiries regarding half a dozen or more different kinds of insect pests in a single day. All these queries have been answered and the remedies suggested have,

when thoroughly tried, given satisfactory results, with a few exceptions where the work was purely experimental.

The work of the office in lines of research has been as broken and fragmentary as that in the study of life-histories and new remedies for pests. There is, however, the difference that the work of collecting insects can be carried on in the odd moments at any railway station or other place where the time is available. The work on the collection of the insects of the State has therefore made some progress, though the greater part of the collections are still unclassified and sadly in need of permanent mounting and labelling. There are now about 18,000 specimens (estimate) in the office.

The group of butterflies has been quite thoroughly collected during the year, and we now have positive records of ninety species out of about one hundred and twenty-five which probably occur in the State. Our collections include some rare and very interesting species.

The group of the Dragon-flies is being collected assiduously by Mr. C. S. Brimley, of Raleigh, with whom we have endeavored to co-operate to some extent.

The Beetles are probably the most important from the agricultural standpoint of any of the groups of insects. Special attention has been given to collecting them, and our collection now shows something over five hundred identified species of various degrees of importance, including forms that are injurious, beneficial and neutral.

The timber interests of our State are very great, and with the disappearance of many valuable trees has come a demand for the better protection of those that remain. The ravages of forest insects is now attracting some attention, and the records of the office show a number of complaints of injury to oak, pine and other trees. This is a line of investigation which is very extensive within itself. The National Agricultural Department became interested in the conditions prevailing in our State, and has established an agent, Mr. W. F. Fiske, at Tryon, in Polk County, who will conduct systematic study and experiments throughout this spring and summer with a view to devising methods of controlling forest pests.

The equipment of the office is supplied from appropriations made by the Board of Agriculture and a very small sum appropriated by the State. Thus far the Experiment Station has not furnished any equipment and it should not be expected to do so until some arrangement can be made by which more experimental work can be done.

It would be a great advance if the Experiment Station could give its moral and financial support in aiding the Agricultural Department to provide for a regular trained assistant to the end that some experimental work could be conducted, for at present almost nothing can be done in this line.

Very respectfully,

FRANKLIN SHERMAN, JR.,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1902—1903.

DR.

To receipts from the Treasurer of the United States as per appropriation for the fiscal year ended June 30, 1903, as per act of Congress approved March 2, 1887.....$15,000.00

CR.

By Salaries	$8,953.32
Labor	1,659.51
Publications	1,117.98
Postage and stationery	263.75
Freight and express	175.28
Heat, light, and water	22.75
Chemical supplies	51.76
Seeds, plants and sundry supplies	460.01
Fertilizers	192.09
Feeding stuffs	550.90
Library	51.27
Tools, implements, and machinery	262.62
Furniture and fixtures	0.00
Scientific apparatus	112.94
Live stock	151.48
Travelling expenses	187.68
Contingent expenses	86.02
Buildings and repairs	700.64
Total	$15,000.00

We, the undersigned, duly appointed auditors of the Corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ended June 30, 1903; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursments $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

(Signed)

S. L. PATTERSON,
B. W. KILGORE,
Auditors.

(Seal).

Attest: A. F. BOWEN.
Custodian.

Nitrification of Different Fertilizers.

By W. A. Withers, A. M., Chemist, and G. S. Fraps, Ph. D., Assistant Chemist.

In a previous bulletin of this Station (No. 176, November, 1900), the authors have compared the rate of nitrification of different fertilizers in an arable soil. The order of nitrification without calcium carbonate, was, dried blood, cottonseed meal, dried fish, tankage, bat guano, bone, and ammonium sulphate. Excluding the ammonium sulphate, this is the order of availability as measured by vegetation tests and solubility in permanganate of potash. In the presence of calcium carbonate, the nitrification was greatly accelerated, and the order became, dried blood, cottonseed meal, bat guano, tankage, ammonium sulphate, bone.

The object of the present work was to compare the rate of nitrification of different nitrogenous materials in different soils, to ascertain if there is any difference from soil to soil.

METHOD OF WORK.

Four soils were selected from the College farm; a rich sandy soil, a poor sandy soil, a rich clayey soil, and a poor clayey soil. The samples were taken in a moist condition, after a rain, and therefore each was provided with its own set of nitrifying and other kinds of organisms. Five hundred grams of soil were placed in a precipitating jar with 5.1 grams calcium carbonate, 0.3 grams combined nitrogen in the form to be tested, and water to make the total water-content of the soil one-third of its saturation capacity. The jars were placed in a water-bath kept at about 35° C., and the loss of water in each jar was restored every Monday and Thursday. At the end of four weeks, the nitrates were leached from 100 grams of the mixture, and their quantity determined by the Tiemann-Schulze method. The combined nitrogen oxidized to nitrates was then calculated to the original weight of the mixture in the jar, which was between 530 and 570 grams, according to the water capacity of the soil and the state of combination of the nitrogen.

The fertilizing materials (except the barnyard manure) were the samples used in the work previously referred to.

RESULTS OF WORK.

Set F. Soil 1782. Durham sandy loam, sandy phase, very poor. Water capacity 27.3 per cent. Humus 0.65 per cent. Absorptive power for ammonia 6.0 per cent.

TABLE I. NITRIFICATION IN SOIL, 1782.
(Milligrams Per Jar.)

Fertilizer.	Total.	Net.	Per Cent.	Rank.
Four weeks—				
Calcium carbonate (blank)	15.3	.0		
Cottonseed meal	17.0	1.7		
Ammonium sulphate	13.3			
Dried blood	19.3	4.0		
Manure	9.3	—6.0		
Five weeks—				
Calcium carbonate	18.8	.0		
Cottonseed meal	32.4	13.6	4.4	100
Ammonium sulphate	33.1	14.3	4.8	105
Dried blood	34.9	16.1	5.4	120
Fish	44.5	25.7	8.6	190
Manure	11.2	—7.6		

Remarks.—On account of the small amount of nitrification which took place, and the fact that duplicate jars were not carried through, no importance can be attached to the rank of the fertilizers found in this experiment.

The net nitrification is obtained by subtracting the blank from the total nitrification.

Set G. Soil 1783. Meadow soil, sandy phase. Water capacity 43.0 per cent. Humus 1.60 per cent. Absorptive power 13 per cent.

TABLE II. NITRIFICATION IN SOIL, 1783.
(Milligrams Per Jar.)

Fertilizer.	Total.	Net.	Per Cent.	Rank.
Calcium carbonate	23.1	.0		
Cottonseed meal	92.0	68.9	23	100
Ammonium sulphate	32.3	9.2	3.	13
Blood	22.3			
Fish	116.9	93.6	31	135
Bone	53.8	30.7	10	43
Manure.	10.4	—12.7		

Remarks.—The high nitrification of fish is striking. The lack of nitrification of blood is probably due to the jar going wrong. Less nitrification took place when barnyard manure was present than when it was absent.

Set H. Soil 1784. Cecil sandy loam, clayey phase. Water capacity 37.2 per cent. Humus 1.90 per cent. Absorptive power 14.0 per cent.

TABLE III. NITRIFICATION IN SOIL, 1784.
(Milligrams Per Jar.)

Fertilizer.	Total.	Net.	Per Cent.	Rank.
Calcium carbonate	15.0	0.	0.	
Cottonseed meal	67.9	52.9	18.	100
Ammonium sulphate	25.2	10.2	3.	20
Blood	51.9	36.9	12.	70
Fish	65.5	50.5	17.	90
Bone	30.1	15.1	5.	30
Manure	16.7	1.7	0.5	3

Set I. Soil 1785. Cecil sandy loam, clayey phase, medium fertility. Water capacity 43.6 per cent. Humus 1.59 per cent. Absorptive power 13.9 per cent.

TABLE IV. NITRIFICATION IN SOIL, 1785.
(Milligrams Per Jar.)

Fertilizer.	Total.	Net.	Per Cent.	Rank.
Calcium carbonate	32.7	0.	0.	
Cottonseed meal	157.4	124.7	42.	100
Ammonium sulphate	189.8	157.1	52.	125
Blood	169.0	136.3	45.	109
Fish	158.9	126.2	42.	101
Bone	60.7	28.0	9.	22
Manure	35.6	−7.		

The humus was determined by the methods of the Association of Official Agricultural Chemists. The method of determining the water capacity is described elsewhere in this report. The absorptive power for ammonia was determined by bringing 100 grams of the soil and 10 grams calcium carbonate in contact with 200 cc. of a solution containing 1 gram ammonium chloride in 208 cc. water. After four hours the solution was filtered off, and ammonia determined in an aliquot part. The results are expressed in percentage of the amount absorbed to the amount offered to the soil.

DISCUSSION OF RESULTS.

The absolute amounts of nitrogen oxidized in the different soils cannot be compared directly, for the reason that each soil had a different number of nitrifying organisms to start with, and it is also

probable that the various groups of bacteria were present in different proportions in the different soils. Indeed, it was desired to obtain a wide variation in the soils and organisms, since the object of the experiment was to discover any variation in the relative amount of nitrification of the combined nitrogen in different forms.

The amount of nitrification and relative rank (compared with cottonseed meal = 100) of the different fertilizers in the different soils are compared in table V. The table also contains in the first column (pasture soil) the results published in Bulletin 176. It must be remembered that no high degree of accuracy is claimed for the figures, for two reasons: first, the nitrifying organisms are liable to vary somewhat in their activity from one jar to another, and second, the determinations were not made in duplicate.

TABLE V. NITRIFICATION IN DIFFERENT SOILS.

Fertilizer.	Pasture Soil (1900).		1782 Poor Soils.		1783. Rich Sand.		1784. Poor Clay.		1785. Rich Clay.	
	Per cent.	Rank.	Per cent.	Rank.	Per Cent.	Rank.	Per Cent.	Rank.	Per Cent.	Rank.
Cottonseed meal	54.8	100	4.4	100	22.9	100	17.6	100	41.2	100
Ammonium Sulphate	31.1	55	4.8	105	3.1	13	3.4	19	52.4	127
Dried blood	54.9	100	5.4	120			12.3	70	45.4	110
Fish	46.5	85	8.6	190	31.2	135	16.5	94	42.1	102
Bone	16.6	30			10.2	43	5.0	28	9.3	22
Manure			—2.5	0	—4.2	0	0.5	3	—2.1	0
Bat guano	35.8	65								
Tankage	34.8	63								

The highest percentage of nitrification took place in the rich clay, and in the pasture soil, which was of a similar nature. The rich sand and poor clay nitrified very nearly the same amounts of combined nitrogen, except in the case of the dried fish. Very little nitrification took place in the poor sand, in even five weeks instead of four weeks for the others. As has been stated before, the number of germs in the different soils varied, since the soil was tested in the natural condition, and though this variation within itself is probably due to the nature of the soil, yet the comparison of the amount of nitrification in them must be made with caution on this account.

The rank of the fertilizers varied somewhat from soil to soil. Taking cottonseed meal as 100 for each soil (although there was a wide variation with it), ammonium sulphate, which varies most, ranged from 13 to 127. Dried blood varied from 70 to 120; fish from 85 to 190; bone from 22 to 43. Some of this variation may be due to error of analysis, or variation in the activity of the organisms.

The barnyard manure is nitrified in only one soil, and then only to the extent of 0.5 per cent. In the other soils there is from —2.1 to —4.2 per cent of nitrification; in other words, there is less nitrification when it is present than when it is absent. It must be borne in mind that the amount of the dried barnyard manure required to furnish 0.3 grams nitrogen is relatively large (16.1 grams) and the course of nitrification might be different with a wider ratio of manure to soil.

SUMMARY.

1. In soils taken from the field in the natural state, the rank of the fertilizers after four or five weeks varied somewhat from soil to soil. The amount of nitrogen nitrified in the form of cottonseed meal being placed at 100, the variations were as follows: Ammonium sulphate, 13 to 127; dried blood, 70 to 120; fish, 85 to 190; bone, 22 to 43. Some of this variation may be due to variation in the activity of the organisms.

2. With 16.1 grams dried barnyard manure to 500 grams soil, less nitrification took place in four or five weeks in three of the soils than when nothing was added. In the fourth soil, 0.5 per cent of the nitrogen was oxidized. With smaller amounts of barnyard manure, different results might be obtained.

Studies in Nitrification *

By G. S. Fraps, Ph. D., Assistant Chemist.

Articles on nitrification have been published by Prof. W. A. Withers and the author in the last two reports of this Station. The chief fact brought out in these articles is that some soils nitrify ammonium sulphate to a greater extent than cottonseed meal in three weeks, while with other soils the reverse is the case. The explanation advanced in the articles referred to for this circumstance is, that the difference is due to the combined influence of three factors:

1. Ammonium sulphate may hinder the action of the nitrifying organisms.

2. The acids produced by their life-activity are detrimental to them unless neutralized.

3. There are organisms which convert organic matter directly to nitrites, as well as those which oxidize ammonium salts to nitrites.

The two ways in which the nitrifying power of a soil may be studied are as follows:

1. *The rate of nitrification in the soil.* The quantity of nitrates in the soil may be determined at the end of different periods of time, when the quantity formed per unit of time during each period is a measure of the rate of nitrification in the soil, or its energy of nitrification, as it will be called in this article. The initial energy of nitrification of a soil is measured by its rate of nitrification during the first period.

2. *The inoculation energy of the soil.* This is taken to mean the power of a soil to bring about nitrification in a sterilized soil which has been placed under proper conditions for nitrification. The measure of the nitrification energy of a given soil is the quantity of nitrates formed in a standard sterilized soil under standard conditions, and in a definite time.

As will be seen later, the nitrification energy of a soil and its inoculation energy are quite different.

The nitrifying power of a soil, meaning both its energy of nitrification and its inoculation energy, depends upon two factors: the number of nitrifying bacteria present, and their activity.

The maximum number of nitrifying bacteria which may be contained in a soil under field conditions, depends upon the nature of the soil itself, since some soils offer a much more favorable medium for the growth of the nitrifying organisms than others. It also depends upon the nature and amount of crop residues, nitrogenous

* Some account of this work was published in the American Chemical Journal *29*, 225, (1903).

fertilizers, humus, and other nitrifiable matters which may be present. With a decrease in the amount of food present, or in the availability of the food, it is obvious that the soil, aside from its nature, offers a much less favorable medium for the reproduction of the nitrifying bacteria.

The number of nitrifying bacteria in any given soil at any time will depend as much upon the conditions to which the soil is subjected as upon its nature. According as favorable or unfavorable conditions prevail, the number of organisms in the soil will be greater or less. Cold, dryness of the soil, and excess of moisture will diminish their numbers, while warmth and a proper amount of moisture will be favorable to their increase. As the number of nitrifying organisms in any soil is subject to fluctuations, according to the season and the weather to which it is exposed, we may consequently expect to find that the nitrifying power of the soil is also subject to variations.

The activity of the nitrifying organisms also varies from time to time. If the rate of nitrification of ammonium sulphate or cottonseed meal is studied under uniform conditions of temperature and moisture, it is seen that the nitrification takes place in stages, a period of activity being preceded and followed by periods of inactivity. That is to say, the rate of nitrification is periodic. A study of the inoculation energy of soils also gives evidence of variations in the activity of the nitrifying organisms.

METHOD OF WORK.

Two kinds of nitrification tests were made. In one kind, the nitrification was carried out in the soil as it came from the field; in the other, the tests were carried out in a sterilized soil inoculated with an active soil. The first will be called *direct nitrification* tests; the second, *inoculation* tests. A large number of both kinds of tests were made in the course of this investigation. The methods used varied slightly at first, but finally the following were adopted as the standard methods. In all the work described in this article, calcium carbonate was added to the soil.

DIRECT NITRIFICATION TESTS.

The soil was sifted through a 5mm. sieve, and 500 grams of it placed in a porcelain dish, and mixed thoroughly with calcium carbonate, water, and cottonseed meal or ammonium sulphate. The mixture was transferred to a pint precipitating jar or fruit jar, weighed, and placed in a large water bath in a dark closet, kept as nearly as possible at 35° C. Every Monday and Thursday, each jar was weighed, and sufficient water added to restore its former weight. At the end of the period, usually three weeks, the proper amount of water was added to the jar, its contents mixed thoroughly

in a porcelain dish, and nitrates determined in 100 grams by the Tiemann-Schulze method. The remainder of the soil was allowed to nitrify further, if desired.

The amount of ammonium sulphate or cottonseed meal which was used for 500 grams soil contained 0.3 grams nitrogen. The ammonium sulphate was added in solution, after the calcium carbonate had been mixed with the soil, and after water had been added to the soil. The calcium carbonate and cottonseed meal were always mixed thoroughly with the soil before any water was added. The calcium carbonate (2.14 grams) was just sufficient to neutralize all nitric and sulphuric acids which would be formed if all the ammonium sulphate were oxidized. In no case did this occur.

Water was used in quantity sufficient to bring the water content of the soil to one-third of its water capacity, after allowing for the water already in the soil, and that to be added with the ammonium sulphate (20 cc.) if any. The method used to determine the water saturation capacity of the soils is as follows:

Fifty grams soil were placed on a porcelain plate in a carbon filter and the whole weighed. Water was added in quantity a little more than necessary to saturate the soil, so that a few drops came through, and the tube was allowed to drain, a cork being placed loosely in it to prevent evaporation. After two hours, the stem of the tube was dried and the whole weighed. Allowance was made for water already in the soil.

INOCULATION TESTS.

These differ from the preceding only in the use of a sterilized soil, and its inoculation with the soil to be tested. The same sterilized soil was used in all the inoculation experiments, being a sandy clay soil which had been in the laboratory in a dry condition for three years. No attempt was made to sterilize the soil completely, because sterilization as regards nitrifying organisms was all that was desired. A thorough drying is sufficient to accomplish this, but the soil used was also treated with chloroform, and then heated to a moderate temperature in an air bath. The water capacity of the soil used was 34.3 per cent.

In case cottonseed meal was used, 20 grams of the soil to be tested were mixed with calcium carbonate and cottonseed meal, and then with 500 grams of the sterilized soil. Water was added in sufficient quantity (one-third of the soil's water capacity), and the whole thoroughly mixed. The nitrification was conducted as described above.

If ammonium sulphate was used, 20 grams of the soil were mixed with calcium carbonate, and then with the sterilized soil. Water was added, and finally the ammonium sulphate in solution. This order was followed because it was not considered advisable to allow the strong solution of ammonium sulphate to come in direct contact with the germs in the inoculating soil.

It must be noted that the 100 grams soil taken for the determination of nitrates did not represent one-fifth of the mixture, since the jar contained 500 grams soil plus water, calcium carbonate, etc. Due allowance has been made for this fact where necessary.

In most of the experiments described in this article, the tests were carried out in duplicate. In many cases, the agreement between the duplicates was satisfactory, but at times a jar would deviate from the normal. In such cases, due judgment must be used in selecting the results. It can not be expected, in dealing with microscopic organisms, which are liable to vary in their activity, sometimes with no known reason, that the same agreement can be obtained as in ordinary chemical analysis.

DESCRIPTION OF SOILS.

1746. Sandy clay soil from a wheat field on College farm. Little humus. Water capacity, 33.0 per cent.

1746a. A second sample, taken three weeks later.

1747. Sandy clay soil, sterilized as described previously. Not from same locality as 1746. Used in all inoculation experiments.

1748. Dark loam soil from a peach orchard on the Experiment Station farm. Contains humus. Water capacity, 34.0 per cent.

1764. Black sandy soil from the Florida Experiment Station. It contained only 0.5 per cent of water when it arrived, and had little nitrifying power.

1764a. A second sample, which had been kept in a well-closed fruit jar since the summer of 1901. It was still quite moist.

1766. Loam from a flower bed on College lawn. Contains much humus.

1766a. A second sample, taken three weeks later.

1768. A garden soil.

1772. Sandy soil from the test farm of the N. C. Department of Agriculture at Tarboro, N. C. Contained only 1.85 per cent water when received, but appeared moist. Water capacity, 27.3 per cent.

1779. Poor, light sandy soil from College farm. No humus. Water capacity, 27.0 per cent.

1780. Rich dark sandy soil from College farm. Contains much humus. Water capacity, 46.0 per cent.

1781. Black sandy soil from garden of State Chemist B. W. Kilgore, at Raleigh, N. C. Contains much humus. Water capacity, 42.5 per cent.

Acknowledgment is hereby made to Chemist H. K. Miller, of Florida, and State Chemist B. W. Kilgore, of North Carolina, for their kindness in furnishing samples of soil.

VARIATIONS IN THE NITRIFYING POWERS OF SOILS.

The irregularities referred to in an earlier part of this paper consisted in variations in the nitrifying power of the same soil. Samples

taken at one time would nitrify vigorously, while another sample, taken a little later, would hardly nitrify at all, under the same conditions. For example, a soil taken from a wheat field May 28 nitrified 143 mgr. nitrogen per kilo of soil in three weeks, while a sample of the same soil taken from the same place three weeks later nitrified only 20 mgr. in the same time.

Similar irregularities were observed in inoculation tests with soils.

These variations are due to the variations in the number and in the activity of the germs contained in the soil. The cause of the variations appear to be as follows:

1. *Variations in the water content of the soil.* It is a well-known fact that a decrease of the moisture of a soil below a certain limit is prejudicial to the activity of the nitrifying organisms. If the soil dries out, the organisms die, or become inactive; if it is moist, they thrive and increase.

2. *Variations in temperature.* Prolonged cold decreases the numbers of the nitrifying organisms, while warmth is beneficial and causes them to multiply.

3. *Abundance of food.* The number of nitrifying organisms in different soils would vary somewhat with the food supply for them in the soil.

4. *Periodicity of the organisms.* When the progress of nitrification is studied in soils under uniform conditions of moisture and temperature and plant food, it is seen that there are periods of activity of nitrification, preceded and followed by periods of comparative rest, during which much smaller quantities of nitrates are produced. This periodicity will be studied in the next section.

PERIODICITY OF NITRIFICATION.

In a number of experiments conducted during the course of this investigation, the rate of nitrification was studied by making determinations of nitrates in the soils at the end of three weeks, and at the end of succeeding weeks. The quantity of nitrogen oxidized per week during each period shows the rate of nitrification in the soil. It is easily seen from a study of the results, that the activity of the organism is periodical, and that a period of activity is preceded and followed by a period of comparative inactivity.

The periodicity of the rate of nitrification of ammonium sulphate and cottonseed meal is shown very strikingly in the curves in Fig. 1. The time is plotted as abscissae, and the number of mgr. of nitrogen oxidized per kilo of soil per week during each period, as ordinates. The curves were chosen to show how the period of greatest activity of nitrification may come during the first three weeks, or during the fourth week, or the fifth week, according to the condition of the soil at the time of starting the experiment.

Table I exhibits the rate of nitrification in 21 jars of soil, conducted in 9 sets, and with organisms derived from 7 different soils.

TABLE I. RATE OF NITRIFICATION.
(Mgr. Nitrogen per kilo of soil oxidized per week.)

Soil and Nutrient.	First Three Weeks.	Fourth Week.	Fifth Week.	Sixth Week.	Total.
Soil 1748, inoculation tests.					
Jar 55, cottonseed meal	17	141	9	8	210
Jar 56, ammonium sulphate	5	59		37_1	138
Jar 57, cottonseed meal	12	109	-57_2	5	91
Jar 58, ammonium sulphate	11	96	6	9	143
Soil 1764, inoculation tests.					
Jar 67, cottonseed meal	2	94	34		133
Jar 68, ammonium sulphate	2	53	18		69
Soil 1766, inoculation tests.					
Jar 72, cottonseed meal	10	106	0		135
Jar 74, ammonium sulphate	2	61	-9_2		57
Soil 1772, direct nitrification.					
Jar 77, cottonseed meal	2	63			70
Jar 79, ammonium sulphate	1	1	0		4
Soil 1772, inoculation tests.					
Jar 81, cottonseed meal	7	108			130
Jar 83, ammonium sulplate	3	62			70
Soil 1781, inoculation tests.					
Jar 91, cottonseed meal	31	66			159
Jar 93, ammonium sulphate	25	49			124
Soil 1781, direct nitrification.					
Jar 85	7	5			26
Jar 87, cottonseed meal	90	30			300
Jar 90, ammonium sulphate	93	39			319
Soil 1746, direct nitrification.					
Jar 47, cottonseed meal	12		69_3	42	218
Jar 49, ammonium sulphate	7		28_3	52	129
Soil 1768, inoculation tests.					
Jar 62, cottonseed meal	1	13	67		83
Jar 65, ammonium sulphate	2	9	64		79

1) Mean of 5th and 6th weeks. (2) Denitrification took place. (3) Mean of 4th and 5th weeks

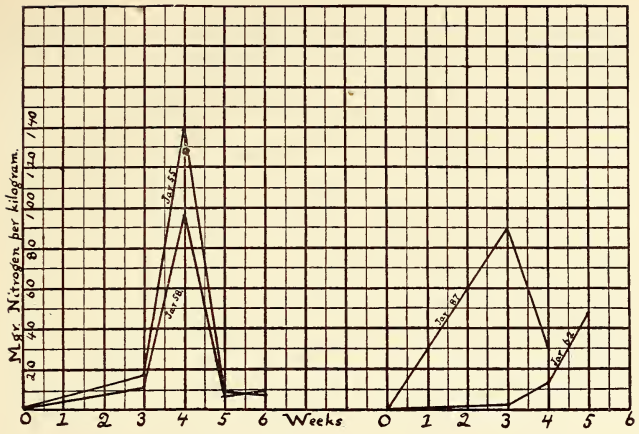

FIG. 1 *. Rate of nitrification of ammonium sulphate and cottonseed meal.

The following statements appear justified by the facts given in the table:

1. The initial energy of nitrification is low in some cases (soils 1766, 1772) and high in others (soil 1781).

2. The rate of nitrification is periodic, reaching a maximum, and then decreasing. The decrease is not due to lack of nitrogen to nitrify, for the soil contains 532 mgr. of nitrifiable nitrogen per kilo, and the total amount of nitrogen nitrified is less than half of this in most cases.

3. In a given soil, the period of greatest energy of nitrification comes at the same time, whether the nitrogen is supplied in the form of cottonseed meal or ammonium sulphate.

4. The period of greatest energy of nitrification has come, as a rule, in the fourth week. This is the case with six of the nine sets of soils in the table. In one set it came in the fifth week, in one set during the first three weeks, and one during either the fourth or fifth week.

5. The quantity of nitrogen oxidized during the first three weeks of a nitrification experiment depends on the activity of the organisms in the soil taken for the experiment, as well as on the number of germs present. In the same soil, and under the same conditions, it may happen that a sample taken at one time will oxidize a large quantity of nitrogen during the first three weeks, while a later sample will not nitrify to any great extent during that time, but will do so if kept a little longer.

* Courtesy of the American Chemical Journal.

CAUSE OF THE VARIATIONS.

The explanation of the variations in the rate of nitrification in soils is probably to be found in the life-history of the organisms. There seems to be a period during which the germs multiply, and little nitrification takes place, then a short period of rapid nitrification, followed by a period of multiplication with little nitrification. How long a period of time it requires for the organisms to complete this cycle of changes, can not be stated. The maximum time required in any of the experiments here given for the maximum of activity of nitrification to occur was five weeks.

The life activity of the bacteria which assimilate nitrogen on the roots of legumes is also periodic. Cultivated outside of the plant, they assimilate nitrogen with difficulty, only 7 mgr. per gram of sugar is consumed by them. When growing in nodules on legumes, according to Nobbe and Hiltner, they are pure parasites, until the bacteria are transformed into bacterioid forms, and then the plant begins to receive the benefit of the nitrogen assimilated by them. The life-history of the nitrogen-assimilating bacteria appears parallel to that of the nitrifying organisms: there is a period of multiplication with little assimilation, followed by a period in which nitrogen appears to be assimilated rapidly.*

According to Schloesing,† in a liquid medium fermentation by yeast increases to a maximum and then decreases to a minimum until the medium is exhausted. In a solid medium, however, the fermentation increases, then decreases, and seems to cease before the medium is hardly exhausted. Stirring causes fermentation to begin again, and it may be started again as often as desired by stirring.

VARIATIONS IN INOCULATION ENERGY.

By the inoculation energy of a soil, we mean its power to induce nitrification in a sterilized soil, provided with nitrogenous substances, and kept under favorable conditions. For the measure of the inoculation energy of a soil, is taken the quantity of nitrates formed in three weeks in a sterilized soil inoculated with an active soil. The method of conducting inoculation tests has already been described. The inoculation energy of a soil depends upon the number of germs in the soil, and on their activity. Any influence which decreases the number of germs in a soil diminishes its inoculation energy.

The inoculation energy of certain soils or cultures was studied in two ways. The first experiments consisted in a comparison of the inoculation energy of the soil with the quantity of nitrates formed in

* When this article was read before the Association of Official Agricultural Chemists, Dr. C. G. Hopkins, of the Illinois Experiment Station, stated that he had observed a periodicity in the nodules on alfalfa roots. The nodules would appear, then begin to disappear, and then become more numerous when the alfalfa was cut for hay.

† Chemisches-Central-Blatt, 1897 2, 501.

it during the three weeks previous to starting the inoculation test, and were as follows: The soils in Series I were allowed to nitrify three weeks, and the quantity of nitrates in them determined. Series II was then prepared by inoculation from Series I. At the end of a second three weeks, Series II was analyzed, and inoculations prepared, forming Series III. It should be stated that the soils in Series I were all inoculated tests, so that the soils used throughout the experiments are exactly the same, and the results are directly comparable.

The results are given in Table II. The ratio of Series I to Series II, and of Series II to Series III, shows the effect of dilution of the actively nitrifying soil with 25 times its weight of sterilized soil, and providing a quantity of nitrogenous matter. The series was not carried out in duplicate, and some of the variations are probably due to a jar going wrong. Excluding the greatest variations, the ratio of the quantity of nitrogen oxidized in three weeks to the quantity oxidized in the soil inoculated from it in the succeeding three weeks, is about 2 : 1 to 3 : 1. As will soon be seen, however, this ratio depends on the activity of the soil, or on the number of organisms present in it.

TABLE II. INOCULATION ENERGY OF SOILS.
(Mgr. nitrogen oxidized per kilo of soil.)

Nutrient.	Series I.	Series II.	Series III.	Ratio I: II.	Ratio II: III.
Cottonseed meal	182	52	81	3.5:1	0.6:1
Ammonium sulphate	176	15	4	12:1	3.8:1
Cottonseed meal	73	35	12	2.1:1	2.9:1
Ammonium sulphate	67	32	25	2.1:1	1.3:1

Series II represents the inoculation energy of Series I at the end of three weeks; Series III the inoculation energy of Series II.

The second method of studying the inoculation energy of soils consisted in determining the inoculation energy of several soils at different periods during nitrification, in order to determine the effect of time upon the inoculation energy.

The method used was as follows: Four jars of soil were kept under standard conditions, and nitrates determined in samples taken at the end of three, four, five and six weeks respectively. At the end of three weeks, samples were used to inoculate a sterilized soil, and nitrates were determined in these for a measure of the inoculation energy of the soils. At the end of four, five and six weeks, similar sets were started. The amounts of nitrates formed in these soils in three weeks represent, therefore, the inoculation energy of the four jars of soil at different periods of time.

The dotted curves in Fig. 2 show the change in the inoculation energy of the four samples of soils with time. The inoculation

energy of the soils increases regularly with the time during which nitrification takes place. It might be imagined that the inoculation intensity of a soil would vary somewhat like its energy of nitrification, but this is not the case, as may be seen by comparing Fig. 1 and Fig. 2. During the fifth week, the nitrification intensity of the soil is very much lower than during the fourth week, while its inoculation intensity is higher than before.

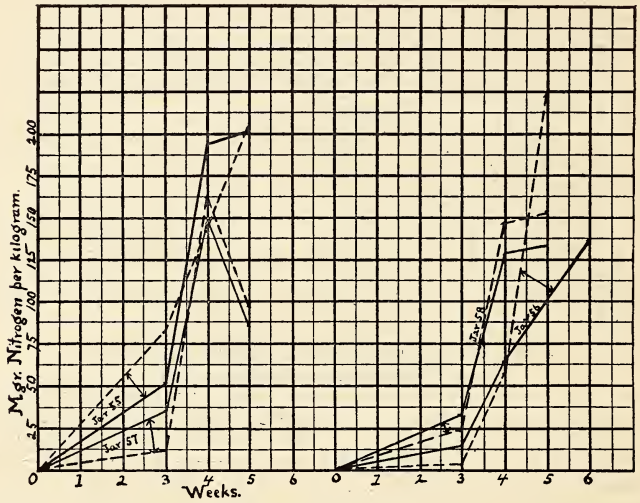

FIG. 2*. Inoculation energy of soils (dotted lines), and total nitrification in same soils (solid lines). Arrows link corresponding curves.

There seems to be very close relation between the inoculation intensity of a soil, and the total quantity of nitrogen oxidized in it, as can be seen by comparing the dotted curves in Fig. 2 with the black ones, which represent the total quantity of nitrogen oxidized. Even in the case in which denitrification took place (jar 57) the inoculalation intensity of the soil exhibits a decrease corresponding with the decrease in the total quantity of nitrates in the soil. Table III contains the figures which were obtained in the inoculation experiment, and also gives the results of an experiment on soil 1781, which leads to the same conclusion as the other one.

A rather striking fact brought out by the table is that the nitrification in the inoculated soil in three weeks is greater than the total amount of nitrogen oxidized in the soil itself in four, five or six weeks, though not in three weeks.

An examination of the table leads to the following conclusions:

1. The inoculation energy of a soil provided with nitrifiable matter, and kept under favorable conditions, increases with time.

* Courtesy of the American Chemical Journal.

2. The inoculation energy of the soil has a close relation to the total quantity of nitrogen oxidized in the soil.

3. The ratio of the total quantity of nitrogen oxidized in the soil to its nitrification energy decreases from 3:1 or 2:1 in three weeks, to 1:1 in longer periods.

4. This ratio depends to some extent on the nitrification energy of the soil.

TABLE III. EFFECT OF TIME ON INOCULATION ENERGY
(Mgr. Nitrogen oxidized per kilo of soil.)

Nutrient.	Three Weeks.		Four Weeks.		Five Weeks.		Six Weeks.
	Total Nitrification.	Inoculation Energy.	Total Nitrification.	Inoculation Energy.	Total Nitrification.	Inoculation Energy.	Total Nitrification.
Series A, derived from 1748—							
Jar 55, cottonseed meal	52	81	193	141	202	205	210
Jar 56, ammonium sulphate	15	4	63	57		219	138
Jar 57, cottonseed meal	35	12	144	158	86	97	91
Jar 58, ammonium snlphate	32	25	128	147	133	153	
Derived from 1781—							
Jar 91, cottonseed meal	93	115	159	123			
Jar 92, cottonseed meal	113	99	171	131			
Jar 93, ammonium sulphate	75	60	124	75			
Jar 94, ammonium sulphate	24	75	138	139			

CAUSE OF VARIATIONS IN INOCULATION ENERGY.

The changes in the inoculation energy of a soil as described above are probably due to the following causes:

1. Increase in the number of germs present in the soil. In a soil provided with an abundance of food for the nitrifying organisms, and kept under favorable conditions, it is self-evident that the number of the bacteria will increase, for a time at least. This increase seems to continue during the whole period of time taken in the study of the changes in the inoculation energy of the soils. In time, the number of bacteria must remain stationary, and then begin to decrease as the food supply diminishes.

2. Increase in the activity of the organisms. At the same time with the increase in the number of nitrifying organisms, there seems to be an increase in their activity. They either multiply more rapidly, or grow in power to nitrify. There may be some connection between this change and the periodicity which we have observed in the rate of nitrification of ammonium sulphate and cottonseed meal. It is also analogous to the increase in activity or "virulence" of nitrogen-assimilating bacteria under cultivation.

THE NATURE OF NITRIFYING ORGANISMS.

In previous articles from this Station by W. A. Withers and the author already referred to, the fact was brought out that some soils nitrify cottonseed meal to a greater extent than ammonium sulphate in three weeks, while with other soils the reverse is the case. The explanation advanced in the articles referred to for this circumstance is, that the difference is due to the combined influence of three factors:

1. Ammonium sulphate may hinder the action of the nitrifying organisms.
2. The acids produced by their life-activity are detrimental to them unless neutralized.
3. There are organisms which convert organic matter directly to nitrites or nitrates, as well as those which oxidize ammonium salts to nitrites.

According to this hypothesis, there are four groups of organisms which take part in the process of nitrification.

Group I convert organic matter to ammonium salts.
Group II convert ammonium salts to nitrites.
Group III convert nitrites to nitrates.
Group IV convert organic matter to nitrites or nitrates.

As stated, this hypothesis is based on the fact that some soils nitrify ammonium sulphate more readily than cottonseed meal, while other soils nitrify cottonseed meal more readily than ammonium sulphate. The work here reported was designed to test this hypothesis more thoroughly.

In the first place, is the difference in the rate of nitrification of cottonseed meal and of ammonium sulphate due to the nature of the soil, or to the nature of the organisms in it? The answer to this question, offered by the experiments described below, is, that the difference is due most largely to the germs, though the nature of the soil is not without its influence.

The experiments which lead to this answer are based on the following considerations: If different samples of a sterilized soil are inoculated with the germs from different soils, and allowed to nitrify ammonium sulphate and cottonseed meal under exactly the same conditions, any difference in the relative amounts of cottonseed meal and ammonium sulphate nitrified, will be due to a difference in the organisms derived from the various soils. That is to say, the only variation is in the nature of the mixture of the organisms which perform the work of nitrification.

The same sterilized soil was inoculated with a number of soils, with the results given in Table IV.

TABLE IV. RELATIVE AMOUNTS OF COTTONSEED MEAL AND OF AMMONIUM SULPHATE NITRIFIED BY INOCULATED SOILS.
(Mgr. nitrogen oxidized in three weeks per kilo of soil.)

Soil Used for Inoculation.	Cottonseed Meal.	Ammonium Sulphate.	Ratio.
1748, loam soil	73	66	1:0.9
1746a, sandy clay soil	100	53	1:0.5
1764a, black sandy soil	99	61	1:0.6
1776a, loam soil	29	7	1:0.3
1772, sandy soil	23	10	1:0.4
1781, black sandy soil	100	84	1:0.8

The table shows the number of milligrams of nitrogen in the form of ammonium sulphate and in the form of cottonseed meal, oxidized in three weeks in a sterilized soil inoculated with a number of soils. The relative amounts of cottonseed meal and ammonium sulphate vary from 1 :0.3 to 1 :0.9, according to the soil used for the inoculation. This variation is certainly evidence that the variation in the comparative rate of nitrification of ammonium sulphate and cottonseed meal is due to variations in the organisms in different soils. That is to say, there seem to be two classes of nitrifying bacteria.

When the nitrification in the inoculated soils is allowed to continue for a longer period of time than three weeks, the relative amounts of nitrogen oxidized sometimes vary.

TABLE V. EFFECT OF TIME ON NITRIFICATION OF COTTONSEED MEAL AND AMMONIUM SULPHATE IN INOCULATED SOIL.
(Mgr. nitrogen oxidized per kilo of soil.)

Soil.	Time.	Cottonseed Meal.	Ammonium Sulphate.	Ratio.
1746a	Five weeks	100	53	1:0.5
	Six weeks	104	156	1:1.5
	Seven weeks	129	187	1:1.5
1768	Three weeks	3	7	*1:2.3
	Four weeks	16	15	1:1
	Five weeks	80	79	1:1
1764	Four weeks	99	61	1:0.6
	Five weeks	133	74	1:0.6
1766a	Three weeks	29	7	1:0 3
	Four weeks	134	68	1:0.5
	Five weeks	135	76	1:0.6
1772	Three weeks	23	10	1:0.4
	Four weeks	130	70	1:0.5
1781	Three weeks	100	84	1:0.8
	Four weeks	165	131	1:0.8

*Excluded on account of the small amount of nitrification during this period.

Table V exhibits the variation in the relative amounts of ammonium sulphate and cottonseed meal, oxidized, with time. The sterilized soil presents conditions favorable to the increase of both classes of organisms, and some variations of this kind is to be expected, but it is not evidence that there is no difference in the organisms which effect nitrification in different soils. Even if we exclude the cases of variation, there is sufficient evidence to establish this point.

Another evidence in favor of the view that there are variations in the nitrifying organisms in soils, is offered by a comparison of the relative amounts of cottonseed meal and ammonium sulphate nitrified in the soil itself, and in the soil inoculated from it. The figures are given in Table VI. It is seen at a glance that though the ratio of nitrification of ammonium sulphate and cottonseed meal varies from soil to soil, there is comparatively little variation from soil to culture. This is a further evidence that the variations are due to the germs in the soils.

TABLE VI. RELATIVE AMOUNTS OF COTTONSEED MEAL AND AMMONIUM SULPHATE NITRIFIED IN SOILS AND IN INOCULATIONS FROM THEM.

(Mgr. Nitrogen oxidized per kilo of soil.)

Soil.	Method.	Cottonseed Meal.	Ammonium Sulphate.	Ratio.
1748	Direct	212	176	1:0.8
	Inoculation	73	66	1:0.9
1746	Direct	176	77	1:0.45
	Inoculation	100	53	1:0.53
1772	Direct	5	3	1:0.6
	Inoculation	23	12	1:0.5
1781	Direct	284	267	1:0.9
	Inoculation	105	85	1:0.9

CULTIVATION OF THE ORGANISMS.

If there are two classes of nitrifying organisms in the soil, it should be possible to increase the relative numbers of one class by cultivation of it in a soil containing cottonseed meal, and the relative numbers of the other class by cultivation in a soil containing ammonium sulphate.

If soils containing cottonseed meal and ammonium sulphate are inoculated from these cultures, the relative amounts of cottonseed meal and ammonium sulphate nitrified should be different in the two cultures, though they are both derived originally from the same soil. This experiment has been tried, and has succeeded, and the results of the work are given in Table VII. In each case, the cultures made in cottonseed meal nitrified a proportionally larger quantity of cottonseed meal than the cultures made with ammonium sulphate. Also,

the cultures made with ammonium sulphate nitrified a large proportion of the nitrogen in the form of ammonium sulphate than in the form of cottonseed meal. It is thus possible to increase the relative numbers of the one group of organisms by cultivating them in a soil provided with the appropriate food.

TABLE VII. EFFECT OF CULTIVATING THE ORGANISM ON THE RELATIVE AMOUNTS OF COTTONSEED MEAL AND AMMONIUM SULPHATE NITRIFIED.

(Mgr. Nitrogen oxidized per kilo of soil.)

	Cottonseed Meal.	Ammonium Sulphate.	Ratio.
Set I. (1746)			
Direct, 5 weeks	176	76	1:0.5
Inoculation, 5 weeks	135	194	1:1.4
Grown in cottonseed meal	225	157	
	240	167	
Mean	233	162	1:0 7
Grown in ammonium	190	200	
sulphate	189		
	190	200	1:1.05
Set II.			
Direct	5	3	1:0.6
Inoculation	256	70	1:0.4
Grown in cottonseed meal	158	34	
	130	47	
	143	41	1:0.3
Grown in ammonium	118	70	
sulphate	114	57	
	116	64	1:0.6

An examination of the table shows that it is possible to increase the relative numbers of either group of organisms by cultivation in the proper medium. That there are two groups of organisms of this kind is in itself not evidence that organisms exist which oxidize organic matter to nitrates or nitrites, however. For we could assume that the germs which prepare cottonseed meal for nitrification by breaking it down to ammonium salts are diminished in relative number when the organisms are cultivated in a medium containing ammonium salts, and this assumption would, in part, explain the facts here given.

It seems probable that there are organisms which nitrify organic matter directly. If they do not exist, it should be possible to increase the rate of nitrification of ammonium salts without increasing the

nitrification of cottonseed meal, but it should not be possible to increase the rate of nitrification of cottonseed meal without increasing that of ammonium sulphate, since the organisms which oxidize ammonium salts must increase in the same proportion as those which prepare the cottonseed meal by converting it into ammonium salts. If all the nitrification is effected with the oxidization of ammonium salts as an intermediate stage, there should be more of these germs in a soil in which 233 mgr. nitrogen per kilo is oxidized in the form of cottonseed meal, than where only 190 is so changed. But in the first case only 162 mgr. nitrogen in the form of ammonium sulphate is nitrified, in the second 200. The fact that ammonium salts, in none of the cases mentioned in this article, are nitrified much faster than cottonseed meal, is another fact in favor of the view that organisms exist which can change organic matter directly to nitrates or nitrites. The only conclusive test would be the separation of the germs.

DETERMINATION OF THE COMPARATIVE NITRIFYING POWER OF SOILS.

The work recorded in this article serves as a basis for a method of determining the relative nitrifying power of soils, which it is believed will lead to very important results. The nitrifying properties of soils may be studied with regard to several points:

1. *Number of germs in the soil.* As has been shown in this article, the number of nitrifying organisms in any given soil is subject to wide fluctuations. As the activity of the germs varies as well as their number, it may be said that at present there is no method for comparing the relative numbers of germs in different soils.

2. *Nature of germs.* It is not considered of practical importance to determine the relative numbers of germs in soils which nitrify organic matter, and which nitrify ammonium salts, since it is probable that both groups of organisms are present in every soil, and their numbers may be increased by proper treatment.

3. *Comparative nitrifying power of soils.* This regards the soil only as a medium for the growth of the nitrifying organisms, and has for its object the comparison of the capacity of different soils to support nitrifying organisms.

The nitrifying power of two soils may be compared in two ways. Of these, the second is to be preferred, since it gives more exact results.

Method 1. *By comparison of direct nitrification tests.* The method is as follows: Nitrification experiments and inoculation tests are made on the soil as it comes from the field by methods described in the earlier part of this paper. The sterilized soil used for the inoculation tests should be of good quality. If the soil is of good quality, the quantity of ammonium sulphate and cottonseed meal nitrified in

it directly in three weeks should be two to three times the quantity nitrified in the inoculation tests, but if the soil is of poor quality, nitrification will go on more rapidly in the inoculated soil than in the soil itself. The application of the method is illustrated in Table VIII. In two of the soils the ratio of the nitrogen oxidized in the soil and in the inoculation from it is between 2 : 1 and 3 : 1, while in the soils which are not such favorable mediums for nitrification, the ratio is between 0.4 : 1 and 0.1 : 1. In the case of soil 1772, a continuation of the experiment for a fourth week shows that it is a much more favorable medium for the nitrification of cottonseed meal than ammonium sulphate. As stated, the second method now to be described is to be preferred for the determination of the nitrifying power of soils.

TABLE VIII. RELATIVE AMOUNTS OF NITROGEN OXIDIZED IN SOILS AND IN INOCULATIONS.
(Mgr. per Kilo.)

Conditions.	Direct	Inoculation.	Ratio.
Good soils—			
1748, Loam soil with humus:			
Cottonseed meal	182	73	2.5:1
Ammonium sulphate	176	67	2.7:1
1781, Garden soil, rich in humus:			
Cottonseed meal	270	93	2.9:1
Cottonseed meal	299	113	2.6:1
Ammonium sulphate	256	75	3.4:1
Ammonium sulphate	281	94	3.0:1
Poor soils—			
1741, Loam soil, little humus:			
Cottonseed meal	37	102	0.3:1
Ammonium sulphate	20	53	0.4:1
1772, Sandy soil:			
Cottonseed meal	7	21	0 3:1
Cottonseed meal	2	24	0.1:1
Ammonium sulphate	3	8	0.3:1
Ammonium sulphate	3	12	0.2:1
1792, four weeks:			
Cottonseed meal	70	156	0.4:1
Cottonseed meal	61	130	0.5:1
Ammonium sulphate	4	70	0.06:1
Ammonium sulphate	3		

Method II. *By comparative inoculation tests.* In this method, the soils to be tested are compared in their nitrifying power with

some standard soil, of good quality, a large supply of which has been secured.

In order to compare the nitrifying power of two or more soils, it is necessary that they should be placed under conditions favorable for nitrification, the conditions being exactly alike for each soil, and each soil should contain exactly the same number of nitrifying organisms with the same activity.

All of the soils are sterilized by heating at a moderate temperature for some time, treating with chloroform, and heating again to drive off the chloroform. The heat used in drying the soils should not be too high. Determinations of the water saturation capacity of the soil are made. Inoculation tests are then instituted on the soils as described in the earlier part of the paper. All the soils to be compared should be inoculated at the same time, and with the same soil, so that each jar of soil will contain exactly the same number of nitrifying organisms with the same inoculation energy. As the number and inoculation energy of the nitrifying organisms in a soil is subject to variations from day to day, it would not do to inoculate some of the soils one day and the remainder the next, but with every set of soils, a comparison should be made with the standard soil.

At the end of three weeks, a determination of nitrates is made in every sample of soil, and since all conditions are the same, with the exception of the soils, the results are directly comparable, and represent the nitrifying power of the soils. If the soil used for the inoculation has a low inoculation intensity, the time of the experiment should be extended.

Table IX shows the application of this method to the determination of the relative nitrifying power of three soils. With these soils, the quantity of water used was one-third of their saturation capacity, which of course varies for the soils. Whether this quantity of water should always be used or not, must be decided by subsequent experiments.

Referring to the table, it is seen that the sandy soil has little power of nitrification. The sandy soil used to illustrate Method I has also little power of nitrification, and less so for ammonium sulphate than cottonseed meal. On the other hand, the sandy soil in Table I., which contains much humus, has a high power of nitrification. These results illustrate the importance of a study of the comparative nitrifying powers of soils.

TABLE IX. RELATIVE NITRIFYING POWERS OF SOILS.
(Mgr. Nitrogen oxidized per kilo of soil.)

Nutrient.	Poor Sandy Soil. 1779.	Rich Sandy Soil. 1780.	Soil. 1747.	Ratio.
Cottonseed meal	2	116		
Cottonseed meal	2			
Mean	2	116		1:56.
Ammonium sulphate	3	68	71	
Ammonium sulphate	3	77	84	
Mean	3	73	77	1:24:26

APPLICATION OF THE METHOD.

As seen above, different soils have very different capacities to support the nitrifying organisms. It is not known clearly why this is so, and how cultivation and treatment of the soil may modify its nitrifying powers. There is a great field for the study of the comparative nitrifying powers of soils in connection with the soil surveys going on in the different States. By comparing the nitrifying powers of the different typical soils, it should be possible to divide them into different groups, according to their ability to support the nitrifying bacteria. This classification having been made, it can serve as a basis on which to determine the different factors which influence nitrification in the different typical soils. It will then become possible to control this very important process in the field, at least to a large extent.

It is believed that this is a very important field for research, one in which the results will have a bearing of great importance for practical agriculture and for agricultural chemistry.

NITRIFICATION IN CLOSED VESSELS.

Some of the nitrification experiments were carried out in Erlenmeyer flask with 250 grams soil, the details of the experiment being otherwise as described in this paper. The flasks were closed at first with cork stoppers, but as those containing cottonseed meal blew up in the course of a few days, the corks were replaced by rubber stoppers bearing capillary glass tubes.

In all the flasks, cottonseed meal putrefied instead of nitrifying. Ammonium sulphate nitrified. With one soil, nitrification in the flasks was compared with nitrification in open jars. The results are as given in Table X.

TABLE X NITRIFICATION IN CLOSED VESSELS.
(Mgr. Nitrogen per kilo soil.)

Conditions.	1746	1748	
	Flasks.	Flasks.	Open Jars.
Blank	17	81	70
Cottonseed meal	2	2	182
Ammonium sulphate	158	141	176

NITRIFICATION OF PROTEIDS.

Determinations were made of the comparative rate of nitrification of cottonseed meal, gelatin, casein and albumen in the presence of calcium carbonate. Results are given in Table XI. The jars are duplicates, and to each jar 0.3 gram nitrogen was added.

TABLE XI. NITRIFICATION OF PROTEIDS.
(Mgr. Nitrogen per kilo soil.)

Jar.	Substance.	Three Weeks.	Four Weeks.
139	Cottonseed meal	136	198
140	Cottonseed meal	168	201
141	Ammonium sulphate	113	220
142	Ammonium sulphate	85	159
143	Gelatin	10	205
144	Gelatin	11	178
145	Casein	5	33
146	Casein (lost)		
147	Albumen	34	184
148	Albumen	20	199

Casein is nitrified much less readily than the other substances. Gelatin and albumen are nitrified slowly during the first period, but so rapidly during the fourth week as to become nitrified practically as much as cottonseed meal and ammonium sulphate.

TABLE XII. NITRIFICATION OF PROTEIDS.

	Three Weeks.		Four Weeks.	
	Per Cent.	Rank.	Per Cent.	Rank.
Cottonseed meal	26.3	100	33.3	100
Ammonium sulphate	16.5	65	21.0	63
Gelatin	1.8	7	21.2	64
Casein	0.9	3	5.5	17
Albumen	4.5	18	32.0	96

NITRIFICATION OF AMMONIUM SALTS.

The rate of nitrification of the citrate, chloride and phosphate of ammonia was compared with that of ammonium sulphate and cotton-seed meal. The tests were carried out in duplicate. The results are contained in Table XII. Each jar contained 0.3 gram ammoniacal nitrogen, and calcium carbonate was added, as was the case in all the work described in this paper.

TABLE XIII. NITRIFICATION OF AMMONIUM SALTS.
(Mgr. Nitrogen per kilo soil.)

Jar.	Substance.	Three Weeks.	Four Weeks.
149	Cottonseed meal	186	243
150	Cottonseed meal	195	268
151	Ammonium sulphate	95	210
152	Ammonium sulphate	90	194
153	Ammonium citrate	42	
154	Ammonium citrate	59	
155	Ammonium chloride	59	94
156	Ammonium chloride	64	100
157	Ammonium phosphate	55	141
158	Ammonium phosphate	55	124

The ammonium salts stand in the following order as regards their susceptibility to nitrification: ammonium sulphate, ammonium phosphate, ammonium chloride, ammonium citrate.

TABLE XIV. NITRIFICATION OF AMMONIUM SALTS.

	Three Weeks.		Four Weeks.	
	Per Cent.	Rank.	Per Cent.	Rank.
Cottonseed meal	31.3	205	42.7	127
Ammonium sulphate	15.6	100	33.7	100
Ammonium citrate	8.5	55		
Ammonium chloride	10.3	67	16.2	43
Ammonium phosphate	9.2	59	22.2	65

SUMMARY.

1. The number of nitrifying organisms in a given soil varies according to the conditions to which the soil is exposed.

2. The activity of the organisms is periodic. There is a period of rapid nitrification, preceded and followed by periods of comparative inactivity. The inoculation intensity of a soil provided with nitrogenous matters, meaning its power to induce nitrification in a steril-

ized soil, increased with the time during the whole course of the experiments.

3. The nitrifying bacteria probably multiply continuously during such an experiment, and there are periods in which they nitrify very little.

5. It is possible to increase the inoculating power of a soil greatly.

6. The difference in the rate of nitrification of cottonseed meal in different soils is due to a difference in the organisms in the soils, since the same differences appear in a sterilized soil inoculated with nitrifying soils.

7. There are two groups of nitrifying organisms in soils, one of which nitrifies cottonseed meal and the other ammonium sulphate. It is possible to increase the relative numbers of one or the other group by growing them in a soil containing cottonseed meal or ammonium sulphate.

8. Four groups of organisms probably take part in nitrification: those which convert organic matter to ammonium salts, those which convert ammonium salts to nitrites, those which convert nitrites to nitrates, and those which convert organic matter to nitrites or nitrates.

9. In order to compare the relative value of the medium which different soils offer for the growth of nitrifying organisms, the soils to be compared must be kept under the same conditions, and each soil must contain the same number of nitrifying organisms, of the same degree of activity.

10. A method is described for determining the comparative nitrifying powers of soils.

11. It is believed that the study of the comparative nitrifying powers of soils in connection with different soil types will be of great value as serving for a basis for study of the different factors which influence nitrification in the different types of soils.

12. In closed vessels, ammonium sulphate nitrifies while cottonseed meal putrefies.

13. Cottonseed meal is nitrified more rapidly in three weeks than gelatin, casein, or albumen.

14. Ammonium sulphate is nitrified more rapidly than ammonium phosphate, ammonium chloride, or ammonium citrate.

Nitrification of Ammonia Fixed by Chabazite.

W. A. WITHERS, A.M., CHEMIST. AND G. S. FRAPS, PH.D., ASSISTANT CHEMIST.

The object of this experiment was to ascertain whether the ammonia fixed by the zeolite silicates represented by chabazite is more or less readily nitrified than ammonium sulphate. The result, it may be stated, shows that the fixed ammonia is nitrified more readily than the other forms.

METHOD OF WORK.

Two hundred and fifty grams of pulverized chabazite were treated with forty grams of ammonium chloride in a liter of water. After two days the chabazite was filtered off and washed. It contained 1.26 per cent nitrogen.

The amount of chabazite containing 0.3 grams nitrogen was mixed with 5.1 grams of calcium carbonate, and then with 500 grams of soil, water was added to one-third of the saturation capacity of the soil, and the mixture placed in a precipitating jar, kept at the temperature of 35° C. in a water-bath. The loss of water was replaced twice a week. With the cottonseed meal and the ammonium sulphate the same procedure was adopted. The time, unless otherwise stated, was three weeks.

The soils are described elsewhere in this report.

RESULTS OF THE WORK.

The results of the work are given in the following table:

TABLE I. NITRIFICATION OF AMMONIATED CHABAZITE COMPARED WITH COTTONSEED MEAL AND AMMONIUM SULPHATE.

(Mgr. Nitrogen per Kgr. soil.)

Soil.	Blank.	Cottonseed Meal.	Ammonium Sulphate.	Ammoniated Chabazite.
Soil, 1746, Sandy clay—3 weeks	31.0	37.3	20.7	167.0
5 weeks	34.2	175.9	76.5	265.9
6 weeks	52.4	217.9	128.6	296.6
Soil, 1746, Sandy clay*	17.1	2.6	156.2	194.7
1748, Dark loam*	81.2	1.6	140.6	288.8
1748, Dark loam	69.8	181.5	176.1	211.5
1764, Black sand	----------	3.3	5.5	51.2
1702, Clay	0.7	1.0	0.7	7.8
1703, Pasture	116.0	166.1	159.6	209.8

*In Erlenmeyer flasks, closed with rubber stopper, carrying capillary tubes. The cottonseed meal did not nitrify.

An examination of the table shows that the ammonium fixed by chabazite is nitrified much more readily than nitrogen in the other two forms. This fact is brought out very clearly if the percentage of nitrification of the nitrogen added to the soil is considered. This is given in Table II.

TABLE II. NITRIFICATION OF THE MATERIALS.

	Cottonseed Meal. Per Cent.	Ammonium Sulphate. Per Cent.	Ammoniated Chabazite. Per Cent.
Soil, 1746, Sandy clay—3 weeks	2.1		45.3
5 weeks	47.2	14.1	77.2
6 weeks	51.8	25.4	81.4
Soil, 1746, Sandy clay*		46.4	59.2
1748, Dark loam*		19.8	69.2
1748, Dark loam	37 2	35.4	47.2
1764, Black sand†	1.1	1.8	17.1
1702, Clay	0.1	0.	2.3
1703, Pasture	16.7	14.3	31.2

* Closed vessel. † No correction for blank.

DISCUSSION OF RESULTS.

It is evident from the results given above that the ammonia fixed by chabazite is much more readily nitrified than ammonium sulphate or cottonseed meal added directly to the soil. This would lead naturally to the inference that the fixation of ammonium salts by zeolitic silicates may play an important part in the nitrification of ammonium salts in different soils. The change of the character of the soil by the addition of the ammoniated chabazite may, however, have also had some effect upon the course of the nitrification.

SUMMARY.

(1.) Ammonia fixed by chabazite is nitrified more rapidly than ammonium sulphate or cottonseed meal.

(2.) Zeolitic silicates in soils may possibly aid in the nitrification of ammonium sulphate by fixing a portion of the salt.

Nitrifying Power of Typical North Carolina Soils.

W. A. Withers, A.M., Chemist, and G. S. Fraps, Ph.D., Assistant Chemist.

In another article in this report by one of us,* a method is described for comparing the nitrifying powers of different soils. The present article is an application of the method to typical North Carolina soils. The soils were collected by the Bureau of Soils of the U. S. Department of Agriculture, co-operating with the North Carolina Department of Agriculture, and acknowledgment is hereby made to State Chemist B. W. Kilgore for his kindness in furnishing samples of the soils in question.

Before making a comparison of the typical soils as regards their nitrifying power, some preliminary study of the method of work was undertaken.

PRELIMINARY WORK.

The object of this work was to compare the nitrifying power of three soils in two sets, so as to see if there was any variation exhibited between the nitrifying powers of the three soils due to the method of work.

Three soils were selected which were expected to vary somewhat widely in their nitrifying properties. Soil No. 1786, from Red Springs, is a gray sandy soil. Soil 1787, Cecil sandy loam, is a clayey soil of medium fertility, from the College farm. Soil 1788, Durham sandy loam, sandy phase, is a very poor sandy soil from the College farm.

Method of Work.—Five hundred grams of soil were mixed with a mixture of 20 grams nitrifying soil and 4.31 grams cottonseed meal (containing 0.3 grams nitrogen), and with water equal to one-third of the water capacity of the soil. The mixture was placed in a precipitating jar and kept in a water-bath at a constant temperature of 35° C. Every Monday and Thursday each jar was weighed, and sufficient water to replace the loss of water was added through a perforated test-tube placed in the soil, and extending about an inch below the surface. The tube remained in the soil during the experiment. At the end of four weeks the soil was mixed thoroughly, nitrates were determined in 100 grams of it by the Tiemann-Schulze method, and calculated to the total weight of the jar, which was always above five hundred grams, according to the water capacity of the soils. Correction was made for the amount of nitrates present in

*G. S. Fraps. Studies in Nitrification.

the five hundred grams of soil at the beginning of the experiment, and the amount added in the 20 grams of nitrifying soil. The determinations were made in triplicate, and the results are discussed below.

RESULTS OF PRELIMINARY WORK.

Set 26 was started Monday, January 19. The results are given in Table I. Soil 1787 was chosen as the standard soil, and the amount of nitrates formed in it was placed equal to 100 for the purpose of calculating the rank of the other soils. The figures given after the name of the soil express the amount of nitrogen as nitrates in 500 grams of soil at the beginning of the experiment.

TABLE I. NITRIFYING POWERS OF SOILS (Set 26).
(Nitrogen oxidized per jar.)

	Milligrams Gross.	Milligrams Net.	Rank.
1786, Red Springs (blank)	1.6		
Jar 201	37.7	33.2	
202	38.2	33.7	
203	44.2	39.7	
Average		35.5	79
1787, Cecil Sandy loam (blank)	2.7		
Jar 204	47.7	42.1	
205	53.4	47.8	
206	49.7	44.1	
Average		44.7	100
1788, Durham Sandy loam (blank)	2.2		
Jar 208	6.4	1.3	
209	12.9	7.8	
210	5.8	.7	
Average		3.3	8
—— 20 grams nitrifying soil	2.9		

Set 27 was started Monday, January 19, and treated similarly to Set 26. The results are given in Table II.

TABLE II. NITRIFYING POWERS OF SOILS (Set 27).
(Nitrogen oxidized per jar.)

	Milligrams Gross.	Milligrams Net.	Rank.
1786, Red Springs	1.6		
Jar 211	29.3	24.8	
212	37.1	32.6	
213	27.0	22.5	
Average		26.6	74
1787, Cecil sandy loam	2.7		
Jar 214	44.7	39.1	
215	42.1	36.5	
216	38.7	33.1	
Average		36.2	100
1788, Durham sandy loam	2.2		
Jar 218	6.1	1.0	
219	12.2	7.1	
220	8.0	2.9	
Average		3.7	14
—— 20 grams nitrifying soil	2.9		

The rank of soil 1786 is 79 in one case and 74 in the other—average 76.5. The rank of soil 1788 is 8 and 14 respectively—average 11. That is to say, under exactly the same conditions as regards nitrifying organisms, moisture, temperature, etc., soil 1786 nitrified on an average only 76.5 per cent of the cottonseed meal nitrified by soil 1787, and soil 1788 only 11 per cent.

These figures may be considered as satisfactory, and the method may be accepted as giving approximately the comparative nitrifying powers of the different soils.

STUDY OF TYPICAL SOILS.

The method of work was the same as that described in the earlier part of this paper, excepting that the loss of water was replaced on Mondays, Wednesdays and Fridays instead of on Mondays and Thursdays. The tests were made in duplicate. The same samples of cottonseed meal and of nitrifying soil were used in all the work, a large supply having been provided at the beginning of the investigation. It should be noted that in none of the experiments described in this article was calcium carbonate added to the soil.

Soil 1787, the Cecil sandy loam, was used as the standard soil for

the experiments. Although this soil was known to possess good nitrifying properties, and was selected for the standard for that reason, it is purely a matter of chance that only one soil exceeded it as a medium for the growth of the nitrifying organisms.

NITRIFYING POWER OF THE SOILS.

The work was conducted in the sets of ten jars each, the results of which are given in the following table:

TABLE III. NITRIFYING POWER OF SOIL.
Nitrogen oxidized per jar.

	Mgms. Gross.	Mgms. Net.	Rank.
Set 28—			
1787, Standard soil	2.7		
Jar 230	97.3	91.7	
231	100.0	94.4	
Average		93.0	100
1795, Tarboro sand	0.5		
Jar 232	18.3	14.9	
233	18.5	15.1	
Average		15.0	16
1796, Norfolk sand	0.8		
Jar 234	22.7	19.0	
235	18.6	14.9	
Average		17.0	18
1797, Porter's loam	0.5		
Jar 236	84.8	81.4	
237	78.3	74.9	
Average		78.1	84
1805, Porter's gravelly loam	0.5		
Jar 238	70.6	67.2	
239	68.9	65.5	
Average		66.3	71
20 grm. nitrifying soil	2.9		
Set 29—			
1787, Standard soil	2.7		
Jar 240	99.1	93.5	
241	100 1	94.5	
Average		94.0	100
1798, Cecil clay	0.5		
Jar 242	29.7	26.3	
243	36.6	33.2	
Average		29.8	32

TABLE III—Continued.

	Mgms. Gross.	Mgms. Net.	Rank
1799, Norfork fine sandy loam	0.5		
Jar 244	52.2	48.8	
245	58.2	44.8	
Average		46.8	50
1800, Porter's black loam	2.2		
Jar 246	99.4	94.3	
247	109.1	104.0	
Average		99.2	106
1801, Durham sandy loam	4.6		
Jar 248	64.3	66.8	
249	64.3	66.8	
Average	2.9	66.8	71
Nitrifying soil (20 gm.)	2.9		
Set 30—			
1787, Standard soil	2.7		
Jar 250	108.0	102.4	
251	lost.		
Average		102.4	100
1802, Porter's red clay	0.8		
Jar 252	76.2	72.5	
253	82.3	78.6	
Average		75.5	74
1803, Herndon sandy loam	0.5		
Jar 254	38.1	34.7	
255	42.8	39.4	
Average		37.1	36
1804, Cecil sandy loam	3.8		
Jar 256	97.6	90.9	
257	94.1	87.4	
Average		89.2	87
1806, Porter's sandy loam	0.4		
Jar 258	72.6	69.3	
259	54.3	51.0	
Average		60.2	59
Nitrifying soil (20 gm.)	2.9		

OTHER PROPERTIES OF THE SOILS.

The water capacity, absorptive power for ammonia, acidity and humus were also determined, and are compared with the nitrifying power in Table IV.

The *water capacity* is the per cent of water which the dry soil will hold. The method for determining it is described in another paper in this report.

The *absorptive power* for ammonia is the percentage of the ammonia absorbed in the form of ammonium chloride. When 50 grams of soil and 5 grams calcium carbonate are brought in contact for 48 hours with a solution of 1 gram of the salt in 208 cc. water.

The *acidity* was determined by the method of Hopkins.* It is expressed in parts of calcium carbonate per million of soil.

The *humus* was determined by the method of the Association of Official Agricultural Chemists.

The samples of soil studied in the preliminary work are also included in the following table:

TABLE IV. PROPERTIES OF TYPICAL SOILS.

	Water Capacity. Per Cent.	Abso'ptive Power. Per Cent.	Acidity. Per Mil.	Humus. Per Cent.	Nitrifying Power.
1795, Tarboro sand	25.1	9.8	1.8	0.51	16
1796, Norfolk sand	29.6	4.0	0.7	0.35	18
1797, Porter's loam	28.0	9.8	.0	0.96	84
1798, Cecil clay	45.0	18.7	5.5	0.85	32
1799, Norfolk fine sandy loam	37.5	10.7	46.4	1.47	50
1800, Porter's black loam	58.5	27.5	3.2	2.86	106
1801, Durham sandy loam	44.0	17.5	70.2	1.95	71
1802, Porter's red clay	41.9	17.8	0.	2.43	74
1803, Herndon stony loam	41.9	17.1	33.1	1.34	36
1804, Cecil sandy loam	36.8	10.7	0.7	1.37	87
1805, Porter's gravelly loam	31.9	16.0	10.8	1.62	71
1806, Porter's sandy loam	30.6	14.3	0.5	0.65	59
1787, Cecil sandy loam	42.0	14.0	3.4	1.30	100
1786, Red Springs	33.0	----------	5.6	----------	76
1788, Durham sandy loam	28.9	6.0	1.3	0.55	11

DISCUSSION OF RESULTS.

An examination of the table does not reveal any connection between the absorptive power, water capacity, humus or acidity of the soil, and its comparative nitrifying power. Most of the soils high in

* See Proceedings of the Association of Official Agricultural Chemists, October, 1902.

humus are high in nitrifying power. Acidity of the soil did not prevent nitrification from taking place. The soils with the lowest nitrifying powers are sands, low in water capacity and humus. The Cecil clay soil, with a high water capacity but somewhat impenetrable to air, and the Herndon stony loam came next.

A striking difference is seen between the two samples of Durham sandy loam. The sample sent in by the soil survey party is high in water capacity, high in absorptive power for ammonia, the highest of the samples in acidity, moderately high in humus, and of good nitrifying power. The sample collected from the mapped soil on the College farm, is the poorest land on the farm, and it is low in water capacity, in acidity, in humus, and lowest of all in nitrifying power.

SUMMARY.

(1.) The nitrifying power of fifteen North Carolina soils varied from 11 to 106, thus showing a great difference in the capacity of different soils to serve as media for the growth of nitrifying organisms.

(2.) The soils with the lowest nitrifying power are sands with low water capacity, low humus, low absorptive power for ammonia, low acidity, and a moderate amount of humus.

(3.) Acidity of the soil did not prevent the growth of the nitrifying organisms.

(4.) A soil with a low water capacity, low absorptive power, or low humus does not necessarily have a low nitrifying power.

The Assimilation of Free Nitrogen by Bacteria.

G. S. Fraps, Ph.D., Assistant Chemist.

Combined nitrogen is essential to the life of all animals and most plants. It occurs in soils.

The combined nitrogen in soils is lost in two ways; first, it is removed by crops, and second, it is washed away by the drainage water from the soil.

Combined nitrogen is restored to the soils in several ways: (a) in rain and snow, in very small amount; (b) in fertilizers and manures; (c) through the agency of organisms which assimilate free nitrogen from the air.

Taking the United States as a whole, and regarding the imports of nitrate of soda, and exports of combined nitrogen contained in wheat, oats, corn, meat, etc., and considering the losses of combined nitrogen in drainage waters, sewage, and in the preparation of manures, it will be found that the country is losing an immense amount of combined nitrogen yearly, an amount which is not at present counterbalanced by the gain which takes place through the conversion of free atmospheric nitrogen into combined forms. The agriculture of the future will look to the maintenance of the fertility of soils as regards combined nitrogen through the utilization of atmospheric nitrogen.

The free nitrogen of the air is caused to enter into combination in several ways:

(1.) *Electrical means.* An electrical spark in a mixture of nitrogen and oxygen may produce a compound, which afterwards unites with water to form nitric acid. The combined nitrogen in rain is due in part to the action of lightning on the air. Electrical methods of producing nitric acid and nitrates from atmospheric nitrogen now find commercial application.

(2.) *By bacteria in symbiosis with legumes.* The bacteria living in nodules on the roots of beans, peas, alfalfa and other leguminous plants enable the plants, by some means not known, to assimilate the free nitrogen of the air, and build it up into plant substance. The importance of the process is becoming more thoroughly understood each year.

(3.) *Mosses and algae* seem to have the power of causing free nitrogen to enter into combination.

(4.) *Bacteria without symbiosis.* Certain bacteria which occur in the soil have the power of assimilating free nitrogen. The importance of their action is not yet clearly understood.

The work here reported, which relates to the bacteria which assimilate nitrogen without symbosis, is merely preliminary. It deals chiefly with the conditions and media best adapted to the development of the organisms, and deals with the mixture of organisms. No attempt has been made to separate the different kinds of organisms which take part in the process, or to eliminate those which do not aid in the assimilation of free nitrogen.

METHOD OF WORK.

After some preliminary work, the following method was adopted: 200 cc. of the culture liquid was placed in a 500 cc. Erlenmeyer flask, with one gram of soil or calcium carbonate if either were required, the flask was plugged with cotton wool, and the liquid sterilized by heating to boiling for a few minutes. For the inoculation of the culture liquid five grams of soil, in the moist condition, were shaken with 100 cc. water, the soil allowed to settled, and 2 to 5 cc. of the infusion were added to the liquid, the same quantity being used for each flask in a set. The determinations were made in duplicate, and correction made for nitrogen in the soil infusion and reagents, by means of a blank test. The blank was made up in exactly the same way as the other, but was sterilized after the soil infusion had been added.

The flasks were placed in a water-bath and kept at 33° for two weeks at first, and afterwards for one week, as there was a little gain of nitrogen during the second week. The contents of the flasks were then transferred to Kjeldahl flasks, evaporated to a paste with the addition of a small amount of sulphuric acid, and nitrogen determined by the Kjeldahl method.

RESULTS OF WORK.

The chief object of the work was to ascertain the most favorable medium for the growth of the nitrogen-assimilating bacteria as ordinarily found in the mixture with other germs in arable soils. Other circumstances, such as the time, the temperature, and to a very slight extent the nature of the soil infusion, were also studied. The results are given below.

NATURE OF THE MEDIUM.

A comparison was instituted between the amounts of free nitrogen assimilated by No. I, the neutral medium of Beijerinck and Van Delden,* consisting of potassium phosphate and soil, with a trace of ferric chloride; No. II, the medium of Gerlach and Vogel,† containing glucose, potassium phosphate, sodium chloride, calcium carbonate, and a trace of ferric chloride, which is essentially alkaline in nature; No. III, containing different proportions of the same ingredients as No. II, but with magnesium sulphate in addition. The composition of the solutions is given in Table I.

* Chemisches Central-Blatt, 1902, 2, 465. † *Ibid*, 1902, 2, 144.

TABLE I. COMPOSITION OF MEDIUMS.
(Grams per 100 cc. solution.)

	No. I. Beijerinck.	No. II. Gerlach.	No. III.
Mannite	2.	0.	0.
Glucose	0.	2.	2.
Potassium phosphate	0.05	0.5	0.2
Ferric chloride	.01	.01	.01
Sterilized soil	0.5	0.	0.
Sodium chloride	0.	0.5	0.2
Calcium carbonate	0.	0.5	0.5
Magnesium sulphate	0.	0.	0.2

In comparing the three mediums the conditions varied somewhat from set to set, but the only difference between the members of the same set was the nature of the culture liquid.

The results are stated as milligrams of nitrogen assimilated per flask.

TABLE II. NITROGEN ASSIMILATED IN DIFFERENT MEDIUMS.

	No. I.	No. II.	No. III.
Set B. No blank	4.0	11.6	----
	3.0	10.8	----
Set C. Corrected for blank	0.5	0.4	7.0
	0.3	4.4	8.5
Set D. Corrected	2.6	----	11.5
Set E. Corrected	0.7	----	6.5
	0.4	----	7.3

Set B was inoculated with soil, and was kept two weeks at 32° C. No blank corrections for impurities in reagents were made.

Set C was inoculated with 5 cc. of the soil infusion mentioned above, and went for two weeks at the room temperature (about 20° C.).

Set D was inoculated in the same way as Set C, and went for two weeks at 32°.

Set E was inoculated with 2 cc. soil infusion, and went for one week at 32° C.

The same soil was used for the inoculation of each of these sets, a large sample of it being kept in a moist condition in the laboratory.

Results.—For the mixture of germs in the soil used, the alkaline medium No. III gives the greatest assimilation of free nitrogen. No. II next, and the neutral medium, No. I, very much less. As Beijerinck states that the addition of calcium carbonate to his medium did not increase the amount of nitrogen assimilated, it is possible

that there may be soils containing nitrogen-assimilating bacteria which develop best in a neutral medium. It should be stated that Beijerinck used a partially purified culture of the germs, and much larger amounts of nitrogen were assimilated than are given in the table above.

EFFECT OF MANGANESE CHLORIDE AND STARCH.

The addition of magnesium sulphate to Medium No. II, having produced much favorable effects, the effect of the addition of manganese chloride to Medium No. III, and of the substitution of starch for glucose was also determined.

Manganese Chloride. In this case 0.025 gm. manganese chloride was added to Medium No. III. The comparison was made at the same time and under the same conditions.

TABLE III. NITROGEN ASSIMILATED PER FLASK.

	With Manganese.	Without Manganese.
Set E	6.1	6.5
	5.4	7.3
	5.8	6.9

No favorable effect is produced by the manganese chloride.

Starch. Two grams of starch were used in place of two grams glucose in Medium No. III.

TABLE IV. NITROGEN ASSIMILATED (Mgr. per flask).

	With Starch.	With Glucose.
Set E	6.2	6.5
	5.6	7.3
	5.9	6.9

No improvement of the medium was produced by the substitution of starch for glucose.

EFFECT OF TIME AND TEMPERATURE.

Time. The nitrogen assimilated in one week in Medium No. III was compared with the amount assimilated in two weeks. The amount assimilated during the second week is very small.

TABLE V. NITROGEN ASSIMILATED (Mgr. per flask)

	One Week.	Two Weeks.
Set D	9.9	Lost
	10.5	11.5
	10.2	11.5

Temperature. This comparison was between 33° C. and room temperature (about 20°). The time was two weeks. No difference was observed, but it is probable that there would have been a difference had the time been one week instead of two. (Compare also Table II.)

TABLE VI. NITROGEN ASSIMILATED (Mgr. per flask).

	33°C.	20°C.
Set D	11.5	12.8
	Lost	11.2
	11.5	12.0

EFFECT OF SOIL.

The effect of soil infusion upon the amount of nitrogen assimilated was determined by comparing a nitrifying soil with the soil from a lawn. In each case 5 grams soil were shaken with 100 cc. water, the soil allowed to settle, and 5 cc. of the liquid used for inoculation.

TABLE VII. NITROGEN ASSIMILATED PER FLASK.

	Nitrifying Soil.	Lawn Soil.
Set D	11.5	9.7

There is a slight difference. The results are too few to draw any conclusion.

SUMMARY AND CONCLUSION.

As has been stated, the work here reported is preliminary to a more complete investigation which will be made later. The results may be summarized as follows:

(1.) The nitrogen-assimilating bacteria were most active in an alkaline medium containing glucose, potassium phosphate, sodium chloride, calcium carbonate, magnesium sulphate, and ferric chloride in the proportions given, less active when the magnesium sulphate was omitted, and very much less active in neutral liquid containing mannite, potassium sulphate, ferric chloride and soil.

(2.) It is possible that in some soils there are nitrogen-assimilating bacteria which are more active in an alkaline medium, and in other soils those which are more active in a neutral medium.

(3.) Addition of magnesium chloride or the substitution of glucose by starch did not increase the assimilation of nitrogen.

(4.) Slightly more free nitrogen was assimilated in two weeks than in one week.

(5.) The nature of the soil used for inoculating the medium is probably of some effect.

This work will be continued.

Determination of Sulphates in Plants.

G. S. Fraps, Ph.D., Assistant Chemist.

That part of the sulphur in plants exists as sulphates, and part in the organic form, has been known for a long time. R. Arendt, in 1856, was the first to distinguish between the organic and inorganic sulphur in plants and to estimate the total sulphur with any degree of accuracy. He extracted the sulphates with acidulated water, and estimated the total sulphur by fusion with alkalies. Ulricht pursued a similar plan.

Arendt (1853) found small amounts (0.04-0.06 per cent) of sulphates in the lower leaves and ears of the oats, more in the upper leaves (0.44-0.22 per cent). Ulricht (1859) states that sulphates are totally absent from the lower leaves and stems of red clover, while present in the upper leaves and the blossom.

Wolff and his associates (1859) give the following quantity of sulphates and organic sulphur as present in the dry matter of green rape:

Distribution of Sulphur in Green Rape. (Wolff.)

	Organic Sulphur.	Sulphates.
	Per cent (S).	Per cent (SO_3).
Seed	1.127	0.020
Straw	0.167	0.021
Chaff	0.310	1.464

Wolff and Yelin (1860) did not find any sulphates in the grain or straw of wheat, in barley, oats, or lucerne. Knop and Ritter (1859) found sulphates in garden beans (0.14 per cent), none in the bean straw.

E. Schulze in 1876 investigated the changes in sulphur during the sprouting of the seeds of the yellow lupine. The finely-ground material was completely extracted with warm water, acidified with hydrochloric acid after separating a small quantity of albumen, and precipitated with barium chloride. As the precipitate did not appear pure, it was fused with sodium carbonate with the addition of a little potassium nitrate, the melt extracted with water, and the sulphuric acid precipitated with barium chloride. The seed contained 1.028 per cent sulphur, and 0.154 per cent as sulphates (0.385 per cent calculated as SO_3). The sprouted seed contained 1.510 per cent sulphates and 1.703 per cent sulphates after 12 and 15 days. An oxidation of organic sulphur took place during the germination.

Tamman (Ber. d. chem. Ges. *19*, 261 (1886) Ref.) obtained 0.359 per cent SO_3 from peas by fusion with sodium carbonate and saltpeter, 0.075 per cent SO_3 precipitated by barium hydroxide from the hot water extract purified with tannic acid. After germination 25 days the sulphates increased to 0.191 per cent SO_3. By boiling the alkaline filtrate from the barium sulphate with hydrochloric acid a second precipitate appeared, due, he says, to the presence of ethereal salts of sulphuric acid. The quantity of this second precipitate from the ungerminated seeds was insignificant as well as from the seeds germinated in darkness, while from those germinated in the light it corresponded to 0.019 per cent SO_3.

Berthelot and Andre (Biedermann's Central-Blatt 1891, 555) investigated the sulphur in different forms in plants, at different stages of growth. They concluded that the sulphur content of the plant increases continuously until it blossoms. The amount of sulphur present in organic compounds reaches its maximum at the time of flowering, and then gradually decreases, partly on account of reoxidation of the sulphur, partly by elimination of volatile sulphur compounds. The proportion of the two forms of sulphur in the seeds varies considerably in different species. In *Avena sativa*, nearly all the sulphur is present in the organic form; on the other hand, in the white lupine only 6.7 per cent of the total sulphur is in organic combination.

SUMMARY.

I have gone thus fully into the literature in order to give a clear idea as to the present standing of the determination of sulphates in plants. It is seen that the quantity of sulphates present may vary considerably in the seeds of different plants, in different parts of different plants, in different parts of the same plants, and in the same plant at different stages of growth. At times, indeed, the amount of sulphur present as sulphates is very small, practically insignificant.

DETERMINATION OF SULPHATES.

The following method was used for the determination of sulphates in several materials:

Five grams substance were mixed well with 50 cc. of a one-per-cent solution of hydrochloric acid, allowed to stand half an hour, filtered and washed with the dilute acid to 250 cc. or more. The liquid was heated to boiling, barium chloride was added, and the determination completed in the usual way.

Instead of the one-per-cent hydrochloric acid, water was used in several cases, but it was found to dissolve organic matter which was afterwards precipitated on coming in contact with the acid.

No sulphur as sulphates was found in the following materials: Corn (grain), peas (grain), green millet, timothy hay, corn silage, peanuts, sorghum, teosinte.

Sulphur as sulphates was found: In oats, trace; crimson clover straw, 0.003 per cent; cottonseed meal, 0.001 per cent; green cow-pea vines 0.085 per cent.

RELATION OF THE SULPHATES TO THE ASH.

It has been suggested that only the sulphates contained in a plant belong rightly to the ash, and that the sulphur in organic combination does not. This statement is based upon the consideration that the ash is supposed to contain only the inorganic constituents of the plant. The ash has, however, always (though incorrectly) been considered to represent the content of the plant in all elements save carbon, hydrogen, nitrogen, and oxygen, and the analysis of the ash has been taken as a basis to calculate the mineral ingredients withdrawn from the soil by plants. Johnson (How Crops Grow) says distinctly in regard to this point:

"It is usual among agricultural writers to confine the term *organic* to the volatile or destructible portion of vegetable and animal bodies, and to designate their ash-ingredients as *inorganic matter*. This is not an entirely accurate distinction. What is found in the ashes of a tree or of a seed, in so far as it was an essential part of the organism, was as truly organic as the volatile portion, and, by submitting organic bodies to fire, they may be entirely converted into inorganic matter, the volatile as well as the fixed part."

It is out of place to maintain that the ash of a plant should be considered as only the inorganic portion of the plant. The object of ash analyses has been chiefly to ascertain the amount of mineral matter withdrawn from the soil by plants, which will probably be one of its chief objects in the future. It is of great importance that we should know the essential constituents of plants, and particularly is this true at present with regard to sulphur, since the amount of sulphur in plants has been so considerably underestimated.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No 4.—OCTOBER 28, 1902.

TREATMENT OF OATS, WHEAT, RYE OR BARLEY FOR SMUT.

Very few farmers realize the full extent of the injury suffered by these cereal crops through the inroads of smut. The smutted plants are dwarfed, therefore escape observation so completely that even very observing farmers often allow as much as 25 to 35 per cent of smut to pass unnoticed. Smut is rarely less than ten per cent in oats, and is frequently 16 to 25 per cent. This is a complete loss to the farmer, as it costs as much in seed, land and tillage to raise the smutted plant as to raise the full head. All of this loss can be turned into a clear profit at a cost of about one cent per acre for material and a very slight outlay of labor. The United States is suffering annually a preventable loss of about $18,000,000 from the smut of oats alone. Our own State is yearly losing between 10 to 20 per cent of her annual oat crop, ranging in value at about $991,516.00.

RATIONALE OF TREATMENT.

The smut of grain is caused by a fungus, the spore (the spore is the reproductive body of fungi, corresponding to the seed in higher plants) of which is carried in the seed to the young grain plant. Smutted plants in the field, and in threshing, shed their spores in the air. These spores are then carried about by the wind, many of them finding lodgment in the seed of neighboring plants. They are thus planted with the grain and the same moisture, warmth, etc., which starts the plant into renewed life quickens the smut. It thus happens that many young plants are, in earliest infancy, attacked by the smut enemy, which, having gained entrance, lurks within the plant until blooming time, when it again breaks forth in its well-recognized form. Only very young plants are susceptible to attack of the smut, therefore if we can so treat the seed of the plants as to destroy the adhering spores of the fungus without injuring the grain, we can enable the young plant to pass the critical stage of its existence in safety. It is thereafter safe. Such treatment is possible. Smut can therefore be practically eliminated from the field. Several kinds of treatment are effective, but of all those known that by formalin is by far the best and cheapest.

TREATMENT.

Formalin can be purchased from a druggist at a cost of from 75 to 95 cents per pound. One pound mixed thoroughly with 40 to 50 gallons of water is sufficient to treat 40 to 50 bushels of grain.

To treat the grain, spread it in a thin layer on a smooth barn floor and sprinkle with the diluted formalin, using either a spraying machine or a watering-pot. Sprinkle so as to thoroughly and evenly wet the grain with the mixture. Then shovel the grain over thoroughly a few times to insure even distribution and cover the pile with canvas, carpets, blankets, or bagging, to keep the fumes of the formalin within. The pile should stand from 6 to 12 hours in this way. The oats may then be readily dried by mixing with air-slaked lime, and the lime may be removed by the fanning-mill. The seed is then ready to sow. It may be stored, but in so doing it is liable to renewed smut infection. The best way is to treat, dry, then sow as soon as is practicable.

In general, one gallon of mixture will suffice to treat one bushel of grain. The formalin should be used at the rate of one ounce to three gallons of water.

Formalin is an irritating caustic which should not be brought into contact with the skin in pure form. In diluted condition it is harmless.

If you try this treatment simply as an experiment, sow the treated seed in a definitely marked portion of your field, using all care to keep the treated seed free from smutted seed. If you are adopting this treatment for your whole sowing, it will be instructive if you will leave a small portion, say one or two drill rows, with the same seed, untreated, thus enabling you to determine the real value of treatment. We would be pleased to have you send a letter to the Station stating the results of your treatment, its cost, labor involved, amount of smut in treated and untreated fields. The amount of smut should be very carefully estimated in per cent from an actual count in the field.

F. L. Stevens,
Biologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 5.—NOVEMBER 12, 1902.

WEEVIL IN GRAIN.

Weevil in corn may be largely avoided by storing it in the husk, but this may not be desirable, and with other grains this suggestion is of no effect. To treat grain after it has become infested it must be placed in a tight or reasonably tight bin or box and treated with carbon bi-sulphide. This is a very foul-smelling liquid which may be had of druggists at about 25 cents per pound. It should be used at the rate of 1½ tablespoonsful to each 100 pounds of grain. It may be thrown directly on the grain in the bin or placed in shallow pans or saucers in the bin and allowed to evaporate. If it is to be thrown on the grain, throw in several places, so that the fumes shall penetrate all parts of the bin. In either case the bin should be at once covered with an oil-cloth or thick blanket to prevent the escape of the fumes and allowed to remain covered for about one day.

This treatment is cheap, effective, easy to apply, and does not hurt the grain or other materials in the least, for either planting or food purposes. Failure in its use must be due either to poor quality of Bi-sulphide or to carelessness in application.

The Bi-sulphide is very inflammable, and no light or fire can be allowed near when it is being used, and for some time afterwards, not even a lamp, cigar or pipe.

FRANKLIN SHERMAN, JR.,
Entomologist.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 6.—DECEMBER 1, 1902.

WEEVIL IN GRAIN AND OTHER STORED PRODUCTS.

There are several different kinds of weevils that attack stored grain and like products, but so far as remedies are concerned, all are subject to the same treatment. The idea which prevails in some eastern localities in the State, that the black weevil in stored grain is the same as the bill-bug which attacks young corn plants in the spring, is entirely incorrect. The grain weevils may be quite easily controlled if treated as soon as discovered.

REMEDIES.

By storing corn in the husk, the damage will be largely avoided, but in many cases this is not desirable, and with other grains this suggestion is of no effect. To treat the grain after it has become infested, it must be placed in a tight bin and treated with carbon bi-sulphide. This is a very foul-smelling liquid, and may be purchased of druggists at about 25 cents per pound. It should be used at the rate of $1\frac{1}{2}$ tablespoonsful to each 100 pounds of grain to be treated. The weight of grain may be estimated, as exactness is not essential. The liquid may be thrown directly on the grain, and the bin should then be covered with an oil-cloth or heavy blanket to prevent escape of fumes of the gas. The whole dose of bi-sulphide should not be thrown into the same spot, but in several places, so that the fumes shall penetrate all parts of the bin. Leave covered for a day.

Another method of applying the bi-sulphide is to place it in saucers or shallow pans, place them in the bin and cover as before mentioned. The rapid evaporation soon fills the bin with the poisonous fumes.

This treatment is cheap, effective, easy to apply, and does not hurt the grain or other materials in the least, either for planting or food purposes. It is the standard remedy for insects in stored grain, flour, meal, groceries, etc. Failure in its use is almost invariably due to poor quality of bi-sulphide, faulty bins, or mistakes in manner of using.

CAUTION.

The bi-sulphide is like benzine in its nature, being very inflammable, and no light or fire of any description can be brought near while

the fumigation is going on, not even a lamp, cigar or pipe. If these cautions are heeded, the material is safe to use.

NOTICE.

We are glad to hear from those who are troubled by insect pests, or are interested in insects of any kind. We especially like to hear from those who use the remedies we suggest, so that we may know if they are satisfactory.

All inquiries about insects *must be accompanied by specimens* when it is possible to procure them, no matter how common or well known the insect may be. Place a number of insects, with some of their food, in a tight tin, wooden, or pasteboard box, wrap neatly, place your name on the outside and mail direct to the undersigned. Make no holes in the box for air. Send letter in envelope by itself stating nature and extent of damages, etc. Need not send stamp for reply.

FRANKLIN SHERMAN, JR., *Entomologist,*
Raleigh, N. C.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 7.—JANUARY 28, 1903.

SILK CULTURE FOR THE SEASON OF 1903.

A small but satisfactory crop of cocoons was produced in North Carolina in 1902. With this experience and improved methods and appliances, we should be able to obtain a larger and better yield in 1903. Last year many of our experimenters made the mistake of failing to provide sufficient room for the worms to expand in. Others failed to give the necessary attention to cleanliness and the frequent feedings that silk worms require. These errors greatly decreased the yield of silk, and should be guarded against this year.

The cocoons were sold in New York at 90 cents to $1.00 per pound, for choked cocoons.

Since silk growing is light, easy and interesting work—suitable for women and children, and can be carried on at home with little or no expense for supplies—it is hoped that the number of silk growers will be greatly augmented this year.

The North Carolina Department of Agriculture will again undertake to find a market for all the good cocoons that may be produced in the State in 1903. The Department will also import a fresh supply of silk-worm eggs and distribute the same to citizens at net cost. The price for eggs will be as follows: Per $\frac{1}{8}$ ounce, 40 cents; per $\frac{1}{4}$ ounce, 75 cents; per $\frac{1}{2}$ ounce, $1.50; per ounce, $3.00. Positively no eggs supplied free. Applications should be made at once to the undersigned, and must be accompanied by the price, in postage stamps or money order. No applications can be received later than March 1.

The United States Department of Agriculture has a small supply of silk-worm eggs for free distribution this year. Those who want these should make application at once to the Secretary of Agriculture at Washington, D. C. Not many can be supplied from this source, as the demand will be very great and the supply is small.

The silk season in North Carolina begins about April 20 and ends about June 1. Full directions for growing silk and planting the mulberry are contained in Bulletin No. 181 of the North Carolina Experiment Station.

GERALD MCCARTHY, *Biologist,*
N. C. Department Agriculture.

Raleigh, N. C., January 26, 1903.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

B. W. KILGORE, Director.

PRESS BULLETIN No. 8.—MARCH 5, 1903.

THE SCAB OF THE IRISH POTATO.

The potato scab is readily recognized by all growers of the potato by the scabby depression in the normally smooth skin of the potato. These scabs may be single or scattered, but are often so abundant as to involve nearly the whole surface of the potato. To the consumer they are of considerable importance, since they necessitate very thick paring, and a consequent loss of the edible portion of the potato. To the farmer who wishes to sell his potatoes, the loss is even greater, as the scabby tubers command in the market a much less price than clean, healthy potatoes.

The scab is due to fungus which grows in the skin of the potato. This fungus on old fields, which have been used repeatedly for potatoes, may be thoroughly distributed through the soil. In ground which has not been used for potatoes so much, the scab causing fungus may be absent. If, however, scabby potatoes be planted in a clean soil the scab will be carried to this soil by such planting, and a scabby crop will result.

One method, then, by which the scab gains access to the field is through the seed. This means of entrance is under the control of the farmer, and may be readily cut off by soaking the seed in a chemical which will kill the fungus adhering to the surface of the potato, and yet not injure the potato itself. Such a chemical is formalin.

To treat your seed potatoes, mix eight ounces of formalin with fifteen gallons of water, and soak the seed in this solution for two hours. Then cut and plant them. The solution may be used repeatedly, but it is well after it has been used two or three times, to either lengthen the time of immersion or to add a little more formalin to make up for any loss in strength. Formalin is a harmless non-poisonous substance (when used externally) which can be used with safety anywhere. It can be purchased at any drug store for about 80 cents per pint.

In many cases the value of the crop has been doubled by this treatment, and yet the treatment itself, including both material and labor, costs only a few cents per acre.

If you are troubled with the scab do not neglect treatment.

F. L. Stevens,
Biologist.

Bulletin No. 182 March, 1903

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

THE APPLE:

1. PROPAGATION, PLANTING, PRUNING, AND CULTURE. By W. F. Massey.
2. APPLES IN NORTH CAROLINA—KINDS GROWN IN DIFFERENT PARTS OF THE STATE. By T. K. Bruner.
3. PREPARING APPLES FOR MARKET. By T. K. Bruner.
4. HOW TO UTILIZE THE SURPLUS APPLE CROP. By Gerald McCarthy.
5. CIDER VINEGAR. By Gerald McCarthy.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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C. W. BURKETT.....Agriculturist.
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FRANKLIN SHERMAN, JR.....Entomologist.
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J. S. JEFFREY.....Poultryman.
B. F. WALTON.....Assistant in Field Experiments.
J. C. KENDALL.....Assistant Dairy Husbandry.
B. S. SKINNER.....Farm Superintendent.
A. F. BOWEN.....Bursar.

The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

PREFACE.

No subject in connection with the agriculture of the State has attracted more attention during the past few years than "Apple Growing." The State Department of Agriculture issued a bulletin on the apple in July, 1900, the demand for which has been so great that the edition is entirely exhausted. The present Bulletin is designed to meet the large numbers of inquiries for information on this subject, and is the production of a number of special workers in the Experiment Station and Department of Agriculture, as follows:

THE APPLE:

1. Propagation, planting, pruning, and culture, by W. F. Massey.
2. Apples in North Carolina: Kinds grown in different parts of the State, by T. K. Bruner.
3. Preparing Apples for Market, by T. K. Bruner.
4. How to Utilize the Surplus Apple Crop, by Gerald McCarthy.
5. Cider Vinegar, by Gerald McCarthy.

There will shortly follow other similar Bulletins, as follows:

1. Tree Fruits, other than apples.
2. Grapes and Small Fruits.
3. Truck Crops.

The present and future Bulletins of the Experiment Station will go to all parties receiving the monthly Bulletin of the Department of Agriculture, and to such others as may make request for them.

B. W. KILGORE, *Director.*

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A. Hoen & Co. Baltimore

YORK IMPERIAL.

THE APPLE:

I. PROPAGATION, PLANTING, PRUNING AND CULTURE.

By W. F. MASSEY, Horticulturist.

The Propagation of the Apple.

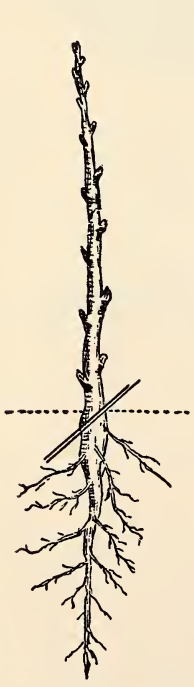
The general method for increasing the apple is by grafting on the roots of young seedlings grown for the purpose. The growing of these seedlings has of itself developed into a large business, since nurserymen find it cheaper to get the seedlings from those who grow them by the million on the deep and fertile soils of the West, than to grow them themselves. What is wanted is a yearling plant with a long, straight tap root, on the crown of which the graft is inserted or rather attached by a sloping cut on root and cion alike. These seedlings are called stocks, and the cuttings placed on them are grafts or cions. Some nurserymen advertise that their trees are all grafted on whole roots. In most nurseries the tap roots are cut into several pieces and a graft placed on each. Those who claim that their trees are on the whole root may perhaps graft only on the crown of the root, but no nurseryman plants the whole root, since they are twelve to eighteen inches long, and can not be conveniently planted without shortening. And shortened they all are. We have tried whole roots and pieces and have never seen any difference between the trees raised on pieces of the root and those on the crown only, for all are really pieces of the root.

Where dwarf apple trees are wanted the French Doucin and Paradise apples are used for stocks. These are grown from stool layers. The Doucin dwarfs the apple slightly for a few years, but finally the developing of the apple roots will make a large tree of it. The Paradise apple, being of a still more dwarfed nature, causes early bearing, and this keeps the tree dwarfish for a longer time than the Doucin does. But the new growth of roots being from the graft will finally cause the tree to become a standard unless the overbearing of fruit permanently stunts it. The roots of the Paradise, rambling in a limited space, make it a shrub, but when the roots are formed by the materials elaborated by the graft the roots take on the habit of the standard and spread widely, and finally make a great apple tree of the dwarf. Dwarfing a fruit tree is sometimes useful for inducing early bearing, but for general orchard purposes we want the full growing standard tree.

When it is thought desirable to grow apple stocks at home the seed should be sown in the fall in strong land that has been very deeply

worked, and where the subsoil is mellow enough to allow the roots to run down straight. The seed should be sown rather thickly and should be well cultivated during the following summer. Most of the seedlings will be large enough to graft the following winter. But as the seedling stocks can be bought usually for less than $5 per thousand, it hardly pays to grow them on a small scale.

February is usually the time for making the grafts. The method used is, as we have said, the whip and tongue graft. The cion should be as nearly as possible the same size as the root upon which it is to be placed. The root is cut at the crown with a long sloping cut. The lower end of the cion is cut with a similar slope to match it. A



Apple Seedling Stock.

Root and Cion Cut for the Graft.

Root Grafted and Tied.

small tongue is cut midways the slope in cion and roots alike. As much as possible of the cambium layer of cion and stock are brought in contact as possible, and the tongues engaging help to hold the graft in place till wrapped around with strips of cotton cloth which have previously been dipped in melted grafting wax, made as follows: The strips are dipped in the melted wax and wrapped in balls. The grafter sits at a bench, and does the work rapidly.

While a few inches of root are enough to start a tree upon, we be-

lieve that the graft made at the crown of the root will usually be found the best, though in a large root I would not hesitate to use more of it.

When Apple Trees Should be Planted in Orchards.

Most inexperienced planters want large trees, and hence it is the common practice to keep apple trees in the nursery for three to four years. The first year from the graft the tree makes a mere switch, and at the end of the season the nurseryman heads them back, and the trees branch in an irregular sort of way, and always too high from the ground for a permanent head in this climate. One of the most important matters in the life of an apple tree, or for that matter of any fruit tree in the South, is that it should be headed low in order to protect the trunk from the sun, and to make the tree less liable to be blown over. Then, too, a low headed tree is an easier one to gather the fruit from. But when the trees start a head in the nursery, it is formed at various heights, and always too high, for the nurseryman knows that people want tall trees, and he therefore does not head them low. When one of these two or three year trees is planted, it is very hard to start the head properly where it should have been started, for if cut back heavily at that time the buds start irregularly from the older wood. All this means that fruit trees of any kind should be planted in the orchard at one year from the bud or graft. The stem is then a mere shoot full of young buds, and can be headed back to any desired height. Orchard writers in the North commonly advise the pruning of all the side branches at transplanting, but to let the central stem remain, and to take the branches from this. This may be best where the winter snows are heavy, but here an open and round headed tree is far better. Planting then one year, or what the nurserymen call "maiden" trees, the head can be made to start just where wanted, giving an orchard of uniform character. In this climate it is well to start all fruit tree tops at 20 inches from the ground. With a long bare stem exposed to the sun there is almost certain to be damage to the bark on the southwest side, and if the stem is tall it is hard to prevent this till the top shades it. But with a stem of twenty inches a simple shingle stuck on the southwest side will be ample protection, and in one season the top will make growth enough to shade the stem from the sun. There is another advantage in planting yearling trees, and this is that the nurseryman can afford to sell them for less than half the money he would have to have for the three year trees, and the freight is much lighter, and the labor of planting less. Of course these little trees will need more careful cultivation, and may be run over by careless plowmen. But any one who plants fruit trees should not only know

how to treat them, but should look after them carefully and not trust to ignorant hands. Some object to low headed trees, that they can not get under them in cultivation. But this is not necessary. The feeding roots of a tree extend out as far or farther than the branches above. Hence if the soil beyond the branches is well cultivated it will be sufficient in the case of any tree.

Dwarf Apple Trees.

It is sometimes desirable to have small trees for planting in limited spaces in gardens, and to supply this demand some nurserymen grow dwarf apple trees. The best stock for this purpose is the French Paradise apple. This is naturally a little bush which bears a profusion of medium sized yellow apples of a bitter-sweet taste, and is of little value for its own fruit. Grafts set on it are induced to grow more slowly and to get into fruit at an earlier age, and by attention to pruning they can be kept in very limited spaces. The French gardeners use these little trees to form what they call a cordon along the garden walks. Wires are stretched on posts about twenty inches from the ground, and the trees are planted along this line about ten to twelve feet apart. They are headed back to the height of the wire and two shoots are allowed to grow at the top. These are tied down as they grow to the wire each way, and the side branches kept pinched back. When the ends of these branches meet the ends of the branches from the next tree, the ends are grafted or inarched together, thus making a continuous line of wood with fruit spurs covering the whole length, and giving fruit in a space we never think of utilizing here. Then, too, by training the trees flat on trellises, and walls, the French gardeners get large amounts of fruit from small spaces which in this country, where we have plenty of room, we never think of using. But while these minute methods of culture may be useful where land is scarce and high and human labor cheap, they are hardly applicable to fruit culture in our wider areas, cheaper land and more costly labor. Our climatic conditions are better and different, and trees do not need the protection of walls here as they do in Europe. The Paradise stocks are produced from stool layers.

Planting an Apple Orchard.

The apple, when properly treated, is a long lived tree. Hence the preliminary preparation of the soil should be of the most thorough character. If the land needs drainage it should be done before any planting is attempted. Complete underdrainage by earthen tiles is the most permanent way to lower the water table in the soil and to enable the air to penetrate the soil and to prevent the souring of the soil. If the land is not already fertile it should be improved

by renovating cropping before the planting of the trees. Crops of cow peas or clover plowed under when fully mature, after having been well fertilized, will make the best possible preparation. The plowing of the land is of the greatest importance, for any lack of deep and thorough preparation can not be well remedied afterwards. Therefore, the plowing should be deep and the breaking plow should be followed by a subsoil plow in the same furrow, so that the whole soil shall be loosened to a depth of 15 to 18 inches all over the whole orchard. If the previous preparation is shallow, and then big holes are dug into the hard and unbroken clay, they will simply act as reservoirs to collect the water and injure the roots of the trees. Hence the breaking should be as deep all over as the holes for planting are to be. It is true that there are rocky hill and mountain sides which are well adapted to the apple, where it will not be possible to make this complete preparation. But such localities are generally blessed with a fertile soil and have abundant natural drainage, and where it is necessary to use such lands for the apple orchard, they will, from their rocky nature, be seldom of such a run down character as much of the old cultivated lands, and they will form an exception to the general rule. We have had the finest of apples on just such land, where previous preparation and subsequent culture were out of the question, but where the virgin soil produced the finest of trees. The lay of the land or the exposure of an apple orchard is not of so much importance in our climate as the situation for a peach orchard, since the apple seldom blooms early enough to be injured by frost. The soil best suited to an apple orchard is a fresh deep clay loam. A mountain cove, where the soil is well drained by rocky debris, but where springs on the mountain above make the soil perennially moist, is the ideal place of all others for an apple orchard. It is in such coves that the celebrated Albemarle pippin of Virginia is grown, and only in such places does it succeed. Such land, freshly cleared from the forest will produce the finest of apples and will be longer lived than in the dry clay soils of the lower valleys.

But whatever the soil or location, the planter of an apple orchard should make up his mind to devote it entirely to the production of apples, and not to follow the usual plan of expecting the land to grow trees and other crops or to furnish hay or pasturage for stock. The common complaint that we can not grow apples as we formerly did is largely due to the fact that the soil has been depleted of the plant food needed by the trees. Farmers realize that it may be necessary to manure land for corn or oats or wheat, but imagine that an orchard can take care of itself like the trees of the forest. The result is decrepid trees and poor or no fruit.

If the land has been prepared as suggested there will be little hole

digging to be done. A little deeper clearing of the cross checks made by the plow in marking off the land will be all that is needed in the way of holes. Rather shallow planting is better than too deep setting of a tree. For apple trees on average fertile soils we would check out the land 30 feet each way. If the land is very fertile and the trees are apt to make an extra growth, it would be better to make the distance 35 feet. On steep lands and mountain sides, where the checking can not be practiced, the trees should be planted on the level contour of the hillside, so that in the cultivation there will gradually be formed terraces to prevent washing. Where the land is full of loose rocks it is a good plan to place them along the lines of the trees to check the downward flow of water and to gather the soil above them. This disposes of the rocks in the way of cultivation and makes them serve a useful purpose.

Planting and Pruning.

Trees, even the yearling maiden trees, always lose more or less of their roots in lifting them from the nursery. Hence at planting there is some pruning needed of the top to balance this loss of roots, and also to start the tree in the proper shape. The roots, too, will need attention. The fine feeding fibres will be mostly dried up, and it is important that they be renewed as speedily as possible. New rootlets start more freely from a clean, smooth cut than from a dried up fibre or a bruised root. Hence before setting a tree we should go over the roots, shorten back any that are over long, and prune with a sharp knife all bruised and broken roots.

Then set the tree but little deeper than it stood in the nursery, as the fresh soil will settle to about the same height. Put the fine surface soil about the roots and see that it comes in intimate connection with them. Ram every inch of soil as it is put in. Do not put water in the hole for the purpose of settling the soil, for in drying it will make cracks to let the dry air in, but depend on a complete ramming of the earth as the hole is filled.

When the trees are set comes the pruning of the top. If the tree is a yearling and a mere switch, this is a simple matter, for it is simply to cut back the switch to the point where you wish to start the head. We head all trees about 20 inches from the ground. Low-headed trees are particularly needed in our sunny climate. A tall stem is apt to get injured by sun scald on the southwest side. It is also more liable to be blown over, and is far more difficult to gather fruit from than a low headed tree.

If you are planting the usual two or three year old trees, which have been headed back in the nursery and have made a sort of head, it will be more difficult to have a uniformly low headed orchard, for

if the old stem is cut back to the point where it should have been, there will be some uncertainty in getting the head started right. For this reason we always use yearling trees whether of apples, peaches, pears or what not, since we can not only get these for less money, but can make better trees of them than from older ones. The yearling stem is lined with fresh buds ready to start at any point. We head the trees back to twenty inches from the ground. The next spring—for all orchard planting in this climate should be done in late fall or winter—we select three or four buds well situated near the end of the stem to form the future head of the tree, and rub off all other buds that start. Close attention should be given this first season to the keeping off of any shoots but those making the head by rubbing them off as fast as they show, so as to throw all the growth into the branches forming the head.

After Culture of an Apple Orchard.

During its early life the apple orchard needs as clean and careful cultivation as any crop on the farm. But the cultivation should not be continued too late in the season as that might induce a late second growth and a tender condition of the wood in the fall. Cultivation should stop in July, and the land between the trees should be sown in cowpeas or crimson clover, or both. In the Piedmont section peas may be sown in July and when they are beginning to drop their leaves, crimson clover seed may be scattered all among the peas and serve as a winter cover to the land. The whole growth is to be plowed under in the spring for the benefit of the trees and the cultivation renewed. (No harm will be done during the early stages of the growth of the trees if the land is cultivated in some low growing hoed crop that comes off early, like early Irish potatoes, but tall crops, like corn, hold the land too late and interfere with the proper growth of the trees.) Growth is what we want in the early stage of the life of the orchard. Hence the renovating crops sown should be used entirely for the benefit of the land, and the trees will be all the better if these crops are aided by an application of acid phosphate and muriate of potash mixed ten parts of the first to one of the last and applied at rate of 400 pounds per acre. Since all is to be returned to the land the fertilizer used will make a heavier growth to plow under and will remain there to feed the trees. Treated in this way we will have well-developed trees in about half the time usually taken. But rapid growth is not conducive to fruitfulness. Therefore, when we have gotten well-developed trees we give some check to this very rapid growth by seeding the land down to grass thickly.

This grass is sown, just as the peas and clover were sown, for the sole benefit of the trees. It is not intended to make a pasture or a

meadow of the orchard. You can get hay or pasturage from it, but you will do it at the expense of fruit. Many writers have condemned the putting of orchards in grass and insist upon constant cultivation. This has mainly arisen from the fact that in most orchards in grass the owners have tried to get something out of the land besides fruit, and in doing this they have impoverished the soil and get no fruit. But the proper keeping of an orchard in grass is the height of good culture. The grass should be mown several times during the summer and all the cut grass left on the land just as we treat a lawn. Then if we give the orchard an annual dressing of the acid phosphate and potash salt the growth of the grass will be fine and the dead mowings will form a deep mulch and protect the trees from drought, while the fallen apples will drop on a soft bed and will be unbruised. The only animal that should ever be allowed in an apple orchard is the hog. With his snout ringed to prevent rooting, the hog may be of value in the orchard as a consumer of wormy fruit.

But the keeping up of the fertility of the soil is of the greatest importance. A full crop of apples removes in the fruit alone three times as much potash as a wheat crop of 20 bushels per acre, and large percentages of other plant food. Therefore, if good apples are wanted the food for the making of them must be supplied if lacking. After the land is in grass a good dressing will be either raw bone meal or pulverized rock, called floats. Three hundred pounds of either of these and 300 pounds of kainit per acre will make a fair dressing. There is no place where the home accumulation of wood ashes will pay better than on the apple orchard.

Pruning the Apple Tree.

I have said little about the pruning of the apple tree, except at the start. The fact is that little hard pruning will be needed if attention is given in the start to get the tree to begin right. After one season's growth the shoots of the season should be shortened back, cutting close above a bud. If the growth is likely to be too spreading, cut to a bud on the inside. If too erect cut to a bud on the outside, so that the shoot from that bud will tend to spread more. Keep all sprouts rubbed off from the stem and all water sprouts from the centre of the tree. When the head is once well formed no cutting will be needed. Simply keep down needless wood by rubbing it out before it needs cutting. Above all, never let an ignorant tree butcher get at the orchard under the pretence of pruning and spoil the trees by cutting out branches here and there without rhyme or reason. In fact, never cut a branch from a tree unless you have a good and definite reason for the cutting. Mere chopping off of limbs is not pruning, for all proper pruning has a definite object in the promotion or checking of growth. During the growing season with young trees we can do most

of the pruning needed with the thumb and forefinger. When a branch threatens to outgrow the others and make the tree lopsided, pinch its growing tip and give the others a chance to catch up. Summer pinching and rubbing out of superfluous shoots will save a great deal of after pruning, and will throw the growth where it is wanted and not waste it in making shoots that have to be cut away later.

Treated as suggested, there is no reason why we should not grow as much and as fine fruit in any section as was ever grown there. Orchards in grass properly treated and used for fruit alone, with the soil kept fertile by annual top dressings and allowing all that grows to decay upon the land, will produce fruit of the finest description if attended to.

The high plateaus west of the Blue Ridge are doubtless the best apple region in the United States, but there is no reason why good apples should not be profitably grown in all the Piedmont section of the State.

Royal Limbertwig.

II. APPLES IN NORTH CAROLINA.

By T. K. BRUNER, Secretary Department of Agriculture.

The adaptability of the soil and climate of the Piedmont and Western portions of North Carolina to the production of the finest apples of almost all varieties has been attracting the attention of growers all over the country, and the desire for additional information along the lines of fruit growing for home consumption and for market purposes has been so persistent that it has been deemed a duty to issue another Bulletin on this subject.

The Board of Agriculture issued a valuable Bulletin in July, 1900, on this topic, but the edition has been exhausted, hence this effort to place reliable information in the hands of enquirers. This determination was quickened by the very excellent exhibit of apples shown at the State Fair in October, 1902. The number of varieties and the size, color and flavor of the specimens shown was abundant proof of the adaptability of the State for the production of the fruit. The wide range of production can best be illustrated by a list of the varieties shown, which is here appended, alphabetically; also, the circumference in inches, around the widest part of the apple, of most all the varieties:

List of Apples Grown in the State.

Arkansas (Mammoth Black Twig)	12	inches	circumference.
Albemarle Pippin (Yellow Newtown)	11	"	"
Baldwin	10½	"	"
Ben Davis	10	"	"
Buff	12½	"	"
Bonum	8¾	"	"
Buckingham	10½	"	"
Bullock (Am. Golden Russett)	8½	"	"
Buncombe	9	"	"
Blackburn	9	"	"
Camack	11	"	"
Cannon	8½	"	"
Carolina Beauty	12	"	"
Domine		"	"
Dula Beauty	12¼	"	"
Esopus (Spitzenburg)	10	"	"
Edwards	9¾	"	"
Fallawater	12¼	"	"
Fall Pippin	12	"	"
Fonville	9	"	"

Gano	11	inches	circumference.
Gloria Mundi	13¼	"	"
Golden Russet		"	"
Golden Pippin	11	"	"
Green Cheese		"	"
Grimes Golden	9¼	"	"
Gilliflower	10x11	"	"
Hoover	13	"	"
Hubbardston		"	"
Horse		"	"
Jonathan	9	"	"
Kentucky Red	10¾	"	"
Lawver	11½	"	"
Lewis Green	11¾	"	"
Limbertwig	9½	"	"
Loy	11¾	"	"
Mattamuskeet	8½	"	"
McAfee	10½	"	"
McCuller	8½	"	"
Missouri Pippin	9½	"	"
Mother	10½	"	"
Milam		"	"
Nickajack	11⅛	"	"
Northern Spy	12	"	"
N. C. Keeper	7¼	"	"
Ohio Pippin (Shannon)	11	"	"
Oliver (Senator)		"	"
Pound (probably same as Buff)	11¼	"	"
Pennock		"	"
Pine Stump	9¾	"	"
Queen Pippin	12	"	"
Rawle's Genet (Janet, Neverfail)	10	"	"
Red Astrachan		"	"
Rhode Island Greening	11	"	"
Romanite (South)	8½	"	"
Rome Beauty	12¾	"	"
Royal Limbertwig	10½	"	"
Sharp's Winter Black	10½	"	"
Shockley	9	"	"
Smith Cider	10½	"	"
Smokehouse	11	"	"
Stayman Winesap	11½	"	"
Stine (Nickajack)	11¼	"	"
Vanhoy		"	"
Vandivere	8¾	"	"

Virginia Beauty	10	inches	circumference.
Walbridge (Edgar Red Streak)		"	"
White Juneating (Yellow May)		"	"
Winter John	8¾	"	"
Willow Twig		"	"
Winesap	11	"	"
Wolf River	15¼	"	"
Yellow Bellflower	10¼	"	"
Yellow Newtown (Albemarle)	11	"	"
Yellow Transparent		"	"
York Imperial (Johnson's Fine Winter)	11	"	"

And about 50 plates of seedlings and some unknown nursery stock.

There were a number of packages of fruit not represented in the above list, which did not arrive in time, which would have lengthened the list to some extent; however, enough is shown to illustrate the great adaptability of the mountain counties to the growing of apples. The "variety" chosen by the grower may be what best suits his fancy; the essential fact is that he can produce on the comparatively cheap mountain lands of this State his "favorites" in as great perfection as they can be grown in any part of the world.

Quality.

Perhaps a few words about quality—aroma, flavor and those things which are liked in an apple—should be introduced here. This is essential since the apple regions are full of many varieties which stand very low in "quality" and which might as well be top grafted with the more desirable kinds. Mr. C. W. Garfield in discussing this subject at the last (1901) meeting of the American Pomological Society, said in part: "When it comes to matters of taste, there is no hard and fast rule with regard to excellence. * * * It is the province of the fruit grower not to antagonize individual tastes, but rather to cater to them in the greatest possible detail. * * * We are constantly expressing our disappointment, because our Northern fruits take second place whenever some tropical species come into the market. We regret that people eat oranges, bananas and breadfruit, neglecting our beautiful Northern apples, and still, in the face of our discomfiture, we magnify the attributes of such apples as the Baldwin and the Ben Davis, because they can be shipped long distances and not be materially injured or bruised by severe handling. Then we expect people to like this class of fruit when placed alongside of the most delicate Southern varieties that are shipped to us with the utmost care in their packing. People eat Ben Davis apples, and then say they are not very particularly fond of apples anyway, when, if their tastes could be satisfied by presenting fruit of the quality of the

Jonathan or of the Melon, there would be an increased demand for the apple. * * * If we expect people to increase the consumption of our fruits we must furnish them the quality and the product that will be attractive to them. We must not only do this, but we must educate people as far as we can in their tastes so that they shall demand the best. This is in the interest of higher living and progressive agriculture."

Downing has designated only three grades for apples, to-wit: "Good," "very good," "best." A fruit that is *fairly good,* does not come up to Downing's lowest grade, and, therefore, should not be grown where it is possible to grow better. The judges in passing upon the fifty odd specimens of seedlings shown at the fair, above alluded to, applied this rule most rigidly, and none of the seedlings examined had "quality" enough behind them to entitle them to be listed as a new and meritorious seedling approaching "very good" in quality. There are so many varieties of apples that in setting a new orchard much may be gained by setting fruit trees which will produce "quality" as well as quantity.

Varieties.

This brings to the front the question of varieties. In North Carolina so diverse and broad is the range of varieties which may be successfully grown, and the choice in size, color and flavor is so extensive that the consideration of the subject becomes one of the most important for the grower.

The list presented below is large, but it is by no means necessary or advisable to try and use them all, but rather to study them with great care in connection with the lay of your orchard land, and to choose from them such as will be most likely to give the best results and at the same time cater to the "whims" of the market you propose to supply.

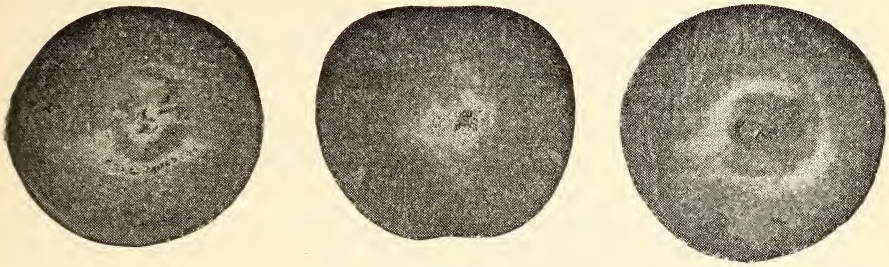
For convenience the list is divided into two sections; the first may be called suitable for family and nearby markets, while the other may be called suitable for market orchard. There are many in the first, which, in certain localities, should be transferred to the second list. But, as indicated above, this is a matter when "quality" has been decided upon, for the individual taste of the grower; for when it comes to growing fruit of fine quality, the man behind the tree has much to do with it. It is not so much a question of rules and regulations or anything like that. If the grower thinks he can produce the finest Grimes Golden in the world, then that is the fruit for him to grow, and so of the other good varieties.

Varieties for Family Orchard and Nearby Markets.

Arkansas (Mammoth Black Twig).—Is of medium size; very good quality; of round, oblate shape; red and yellow in color; mild in

flavor; late ripening; good in kitchen and for market. This apple originated in Arkansas, and promises to give good results in the Piedmont counties of the State.

Benoni.—Small to medium; round, oblate; yellow, with red stripes; mild, pleasant flavor; quality very good; ripens early and especially commended as a dessert fruit.



Bonum

Bonum (formerly Magnum Bonum).—Medium in size; oblate in form; red and sometimes faint yellow striped—red predominating—of delightful mild flavor; yellow flesh; of very good quality; ripens in early autumn, and is one of the finest dessert apples grown. It is especially adapted to the whole of the Piedmont region of North Carolina, where it is esteemed as the best apple of the early autumn season. It is of North Carolina origin.

Bough (Sweet).—Medium to large in size; round, conical form; yellow; sweet pleasant flavor; very good quality; ripens early, and is a fine dessert fruit. It has been grown to perfection in the upper Piedmont region.

Buff (Granny Buff).—Tree vigorous, upright, productive; fruit very large, of roundish oblate, irregular form; color whitish yellow, overspread with broad splashes and stripes of crimson; quality good. A poor shipper, December to January. Originated in Haywood County, N. C. Esteemed for kitchen and drying.

Bullock (American Golden Russet).—Small to medium size; oblate; conical form, yellow russet in color; mild flavor, and very good quality. This apple is especially good in upper Piedmont region, and will do pretty well in the middle section.

Buncombe (Red Winter Pearmain).—Medium size, round, oblate conical, rich carmine, yellow-red in lightest part, mild flavor, juicy and tender—a famous North Carolina seedling—of good quality, late ripening, and may be kept until New Year, and especially good for the mountain region.

Buckingham (Fall Queen).—Is of medium size, very good quality, oblate conical shape, green, yellow and red in color, of mild flavor, late in ripening, and is of value both in the kitchen and for market. It originated in Virginia, and is grown in perfection in this State.

There are a number of synonyms for this apple in this State, such as "Water Queen," "Queen Pippin," "Red Pippin," etc.

Carolina Beauty.—Is of a medium size, very good quality, round and oblong in shape, dark red in color, ripens late, and is of value in the kitchen and for market. This apple originated in North Carolina, where it is successfully grown in the middle section.

Collins (Champion).—Is of medium size, and of very good quality, oblate in shape, striped in color, late ripening, and good for market purposes. It originated in Arkansas, and has been successfully grown in this State.

Chenango.—Medium large in size; oblate conical shape; yellow and red in color; mild flavor and very good quality. Suitable for any part of the State.

Colton (Early).—Medium size; round; yellow; very good quality; ripens early, and esteemed as a dessert fruit. Has been grown in east and west North Carolina with fair success.

Cullasaga (probably should be spelled *cullasaja or cullasagee*).—Medium to large in size; round, conical in form; yellow and red in color; mild in flavor, and of fair quality. Ripens late, and is suitable for market. Originated in North Carolina.

Esopus (Spitzenburg).—An oblong, conical, red apple, of mild flavor; of medium to large size; of the finest quality for dessert; ripens late, and a fairly good keeper. Originated in New York State, and grows well in our mountain counties. Rather shy bearer.

Fall Pippin.—Large size; round, oblate conical shape; yellow and red in color; mild flavor; quality good to best; suitable for mountain counties.

Fallawater.—Very large, round, conical, yellowish green with light purplish blush; of rich mild flavor, very good quality; ripens in mid-autumn, and originated in Pennsylvania. It grows to perfection in Yancey and other western counties, and is much esteemed for both kitchen and market.

Gloria Mundi.—Very large; oblate; yellow; of good quality. They are esteemed for their enormous size. They have been grown to nearly two pounds weight in this State, and would be profitable for market when hand-picked, and carefully wrapped before shipping. The Ohio or *Shannon Pippin* is a very similar large variety, and will do well in the mountain counties.

Gravenstine.—Large attractive apple; irregular oblate form; yellow and red in color; mild acid flavor; quality from good to best; ripens medium early, and is commended for dessert, kitchen and market. Especially good in mountain counties, and originated in Germany.

Green Cheese.—Medium size; oblate irregular form; green and yellow color; mild flavor of very good quality. Ripens late, and is suitable for western part of the State.

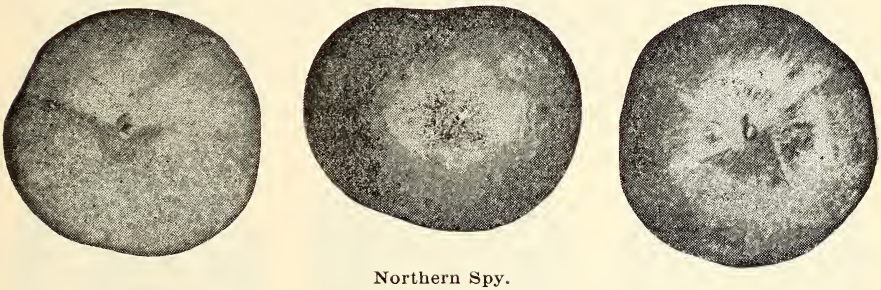
Horse.—Large, yellowish green, with blush on cheek, of mild flavor, good quality, and among the best known of the late summer apples; one of the most useful for kitchen and drying. It is good for all middle North Carolina.

Jefferis.—Medium size; oblate conical form; yellow, red-striped; mild flavor and very good quality. Suitable for mountain counties.

Melon.—A medium size, round, oblate conical apple, yellow, with red stripes; mild flavor; very good quality; ripens late, and is in high repute for dessert and market. Suitable for mountain counties.

Mother.—Medium size; round conical form; yellow and red in color; mild flavor, and very good quality. Medium late, and suited to Piedmont and western North Carolina.

Newton Spitzenburg.—Medium size; oblate conical form; yellow, with red stripes; mild and of very good flavor. Ripens late, and recommended for eastern part of the State.



Northern Spy.

Northern Spy.—Rather large in size; oblate conical in form; yellow, red-striped in color; mild, spicy flavor; of very good quality; medium early to ripen, and highly esteemed for dessert, kitchen and market. Originated in Pennsylvania.

Oldenburg.—Of medium size; oblate form; yellow, red-striped; acid flavor; good quality; early ripening, and good in kitchen and for market.

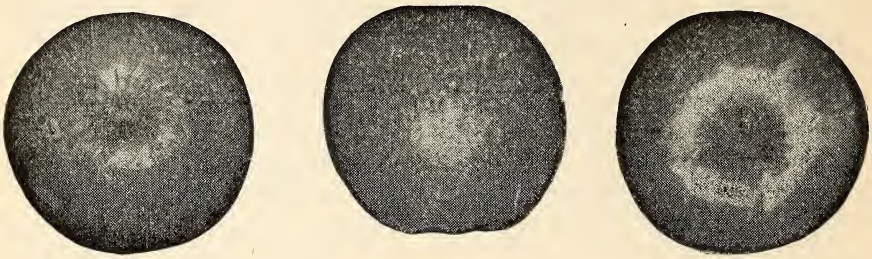
Paragon is medium large in size, of very good quality, round, conical in shape, yellow and red in color, mild flavor, late to ripen, and a good dessert and market apple. It originated in Tennessee, and grows to great perfection in the western part of this State, and fairly well in the middle region.

Pryor, Red.—Medium size; oblate, irregular form; green, yellow and red in color; mild flavor, and very good quality; ripens late, and should do well in the middle and eastern parts of this State.

Red Astrachan.—Is a large apple, round, conical in form and red, green and yellow in color, has an acid flavor, and is of very good quality. It ripens early, and is desirable for kitchen and market, doing well in upper Piedmont and western North Carolina.

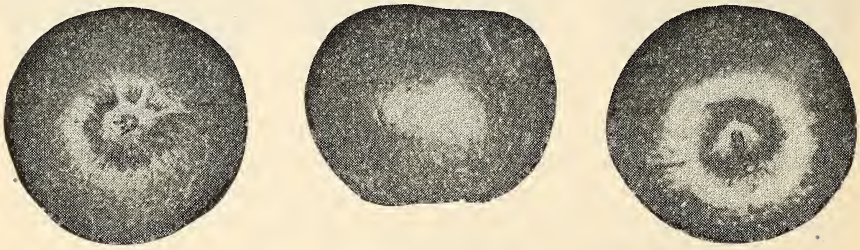
Red June (Carolina).—Small to medium in size, ovate, conical in

form, is red, or red and yellow striped in color, mild juicy flavor, of good quality, and much esteemed because very early in ripening, and as a dessert and market fruit.



Rome Beauty.

Rome (Beauty) is a large apple of good quality, rounded cone in shape, yellow-red striped in color, of mild flavor, medium late in ripening, and is valued as a dessert, kitchen and market fruit. Originated in Ohio, and grows to perfection in western North Carolina, and quite successfully in the middle regions of the State.



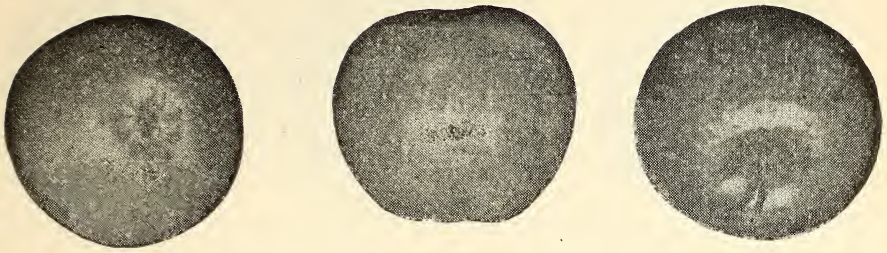
Royal Limbertwig.

Royal Limbertwig.—A large new seedling of the old Limbertwig, of better quality, red and yellow in color, ripens in the autumn and is not the best of keepers. A showy fruit, and good for autumn market.

Stayman Winesap.—A large apple of very good quality, round to oblate conical in shape, red color, late to ripen and a favorite on table and in kitchen, and good for market; originated in Kansas.

Smokehouse.—Medium to large in size; round oblate form; yellow-red in color; mild flavor, good quality; ripens medium late, and will grow in any part of the State.

Summer Pearmain.—Medium size; round conical form; red-russet in color; mild in flavor, and from very good to best in quality. Ripens rather early in middle North Carolina, but should do well from the foot-hills to tidewater.



Shockley.

Shockley.—Small to medium size; round conical form; yellow-red in color; mild flavor, good quality; ripens late, and should do well in middle and eastern North Carolina.

Virginia Beauty.

Virginia Beauty.—Is medium to large in size; round, conical in shape, beautiful rich dark red in color, mild but rich fruity flavor, flesh cream color, quality very good to best; ripens middle of October to middle of November, according to locality, and keeps until midwinter; bears shipping well, and is esteemed for dessert and market purposes.

White Juneating (Yellow May).—Medium small; round; yellow-red blush; very good quality; ripens early, and especially commended for eastern North Carolina.

White Pippin.—Large apple; round oblate form; white, yellow and red coloring; mild flavor, very good to best quality; ripens late, and grows to perfection in the mountain counties.

Wine (Hays).—Large apple; round oblate form; yellow-red color; mild flavor, and is very good quality; recommended for middle North Carolina.

Wolf River.—Very large, round oblate, whitish ground, overspread with splashes and stripes of deep red; mild flavor, of good quality; is an autumn fruit esteemed for kitchen and market; originated in Wisconsin.

Yates.—Small size; oblate conical form; yellow, red striped; mild flavor, and good quality. Ripens very late, and is recommended for eastern North Carolina.

Yellow Transparent.—Medium large in size; irregular conical form; white and yellow color; acid flavor; very good quality; ripens early, and recommended for middle North Carolina.

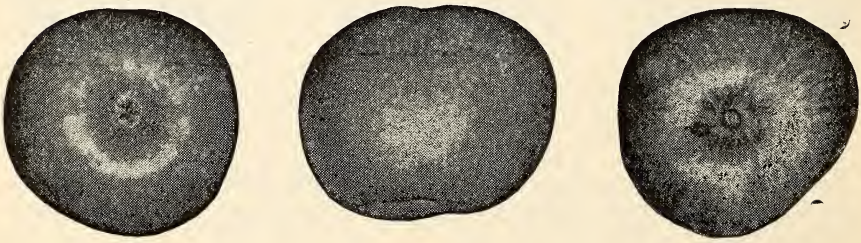
There are still quite a number of varieties which might prolong this list, as a glance at the varieties shown at the Fair will demonstrate, yet the selections include the best of them and afford ample room for the selection of such an orchard as is contemplated under this heading.

New Varieties for Market Orchard.

This means a commercial orchard; an orchard designed to meet the wants of the markets, and from which may be supplied thousands of barrels or boxes of a single variety.

A market orchard should be set with but a few varieties, and they should be selected so as to ripen in succession. This will give constant work in the orchard during the entire fall, and in that way simplify the questions of gathering, packing and shipping.

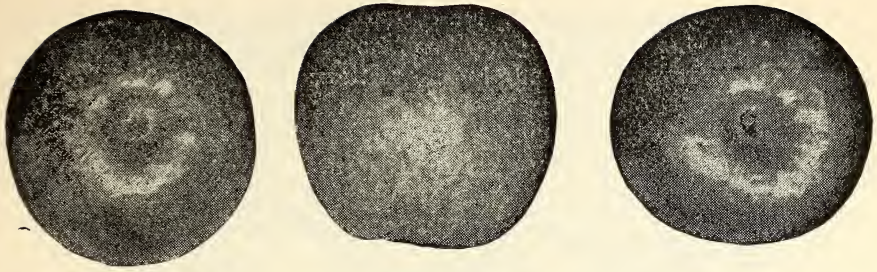
While quite a variety are included in the list, as said above, only a few should be selected, and those chosen should form the succession in ripening; above all things choose such fruit as your lands will best grow and which appeal to your personal fancy, as you are far more likely to succeed with varieties which appeal personally to your taste. As said before, get the man behind the tree for good results.



Albemarle Pippin.

Albemarle Pippin.—Large, roundish, slightly ribbed, yellowish-green when grown, and rich yellow when ripe; firm flesh, sub-acid, rich flavor, of best quality, and a fine market apple where the lands are suitable. Requires rich, black, moist soil in mountain coves, where it will mature to perfection. It is not suited to other localities, and can only be recommended for those favorably located; to such it is the best apple to grow for market. Ripens late, and keeps well. (Same as Yellow Newton.)

Ben Davis.—Medium to large, round ovate in shape, yellow-red striped in color, mild flavor, good quality, but not valued locally for



Ben Davis.

table; excellent keeper and good shipper, but does not bring the highest prices. Ripens late.

Camack ("Spitzbergen" in western North Carolina is a localism, and should not be applied to this apple)—is of medium size, perhaps below medium, though it sometimes reaches ten ounces in weight. It is round and conical in shape; and red, yellow and green in color, the colors blending, but not striped; sweet mild flavor, and of good quality. Ripens late, and is a good keeper. It is esteemed as a dessert and kitchen fruit, and bears shipping very well.

Gano is large in size, of fairly good quality, irregular oblate in shape, yellow, red striped in color, mild flavor, ripens medium late, good market variety; originated in Tennessee, and grows to great perfection in North Carolina.

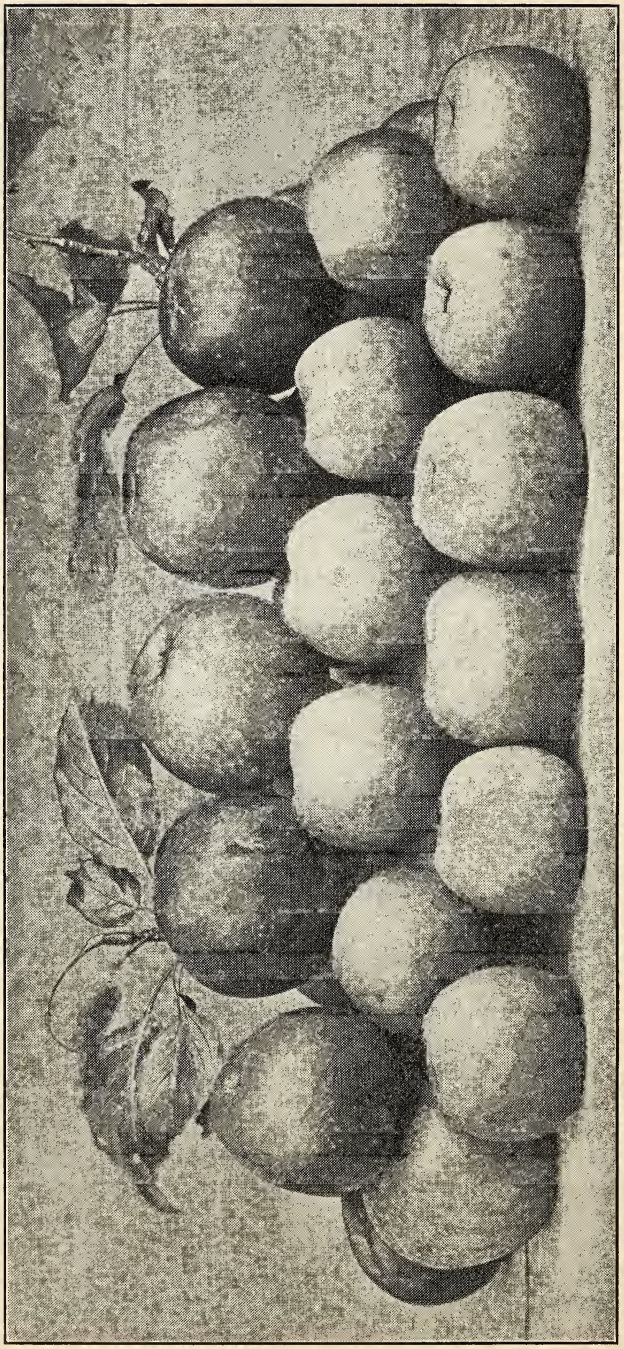
Grimes Golden.—Medium size; round, oblate conical form; yellow; mild flavor and quality from good to best. Ripens late and esteemed as a dessert apple; recommended for middle and western North Carolina.

Hoover.—Medium to large in size, round oblate in form, deep dark red in color, sometimes showing indistinct stripes; is mild, but has a very pronounced fruity flavor, of fairly good quality, and is esteemed for its kitchen and market qualities. It is a mountain apple, ripens late, and is a good keeper. Originated in western South Carolina.

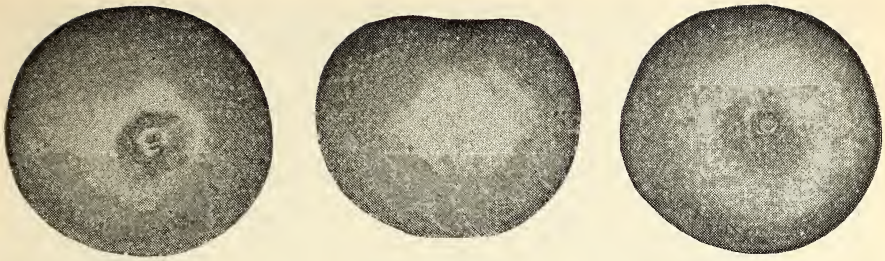
Jonathan.—Medium size, round conical form, rich red with yellow blush, mild flavor, very good to best quality, ripens late, esteemed as a dessert fruit; originated in New Hampshire, and is a good keeper and shipper.

Kinnard.—This apple originated in Tennessee, is of medium size, oblate conical shape, yellow and red in color, of mild flavor, and very good quality, and is recommended for the mountain section.

Limbertwig.—This is one of the best known of the North Carolina apples. It is especially adapted to the eastern slopes of the mountain counties and the higher table lands of the upper Piedmont plateau. It is slightly below medium in size, and round and slightly conical in shape, and the color is red predominating with some yellow on cheek. It is mild in flavor, firm crisp flesh, and of fair quality. Its chief



Grimes Golden (at bottom), Hoover (5 at top).



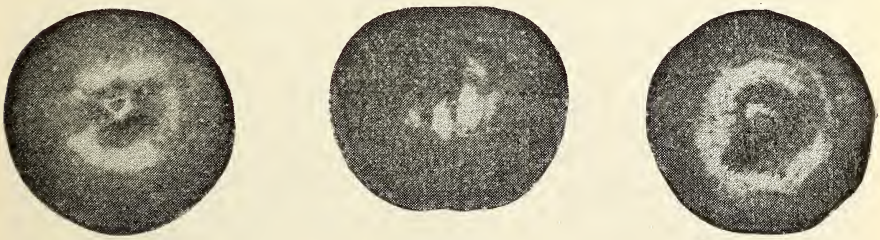
Red Limbertwig.

value is its wonderful keeping quality, ripening very late, and keeping until the spring. It therefore is desirable for market, with the best of shipping qualities.

McAfee.—(Locally known in western North Carolina as Stine), is medium to large in size, round oblate in form, and is yellow, green and red striped in color. Has mild flavor, very good quality, and late to ripen. It is desirable for market, and is a good all around apple for the western part of the State.

Missouri Pippin.—A good sized apple of round conical form, yellow with red stripes, mild flavor and late ripening, and is a market apple—about Ben Davis quality—and a good bearer. Missouri origin.

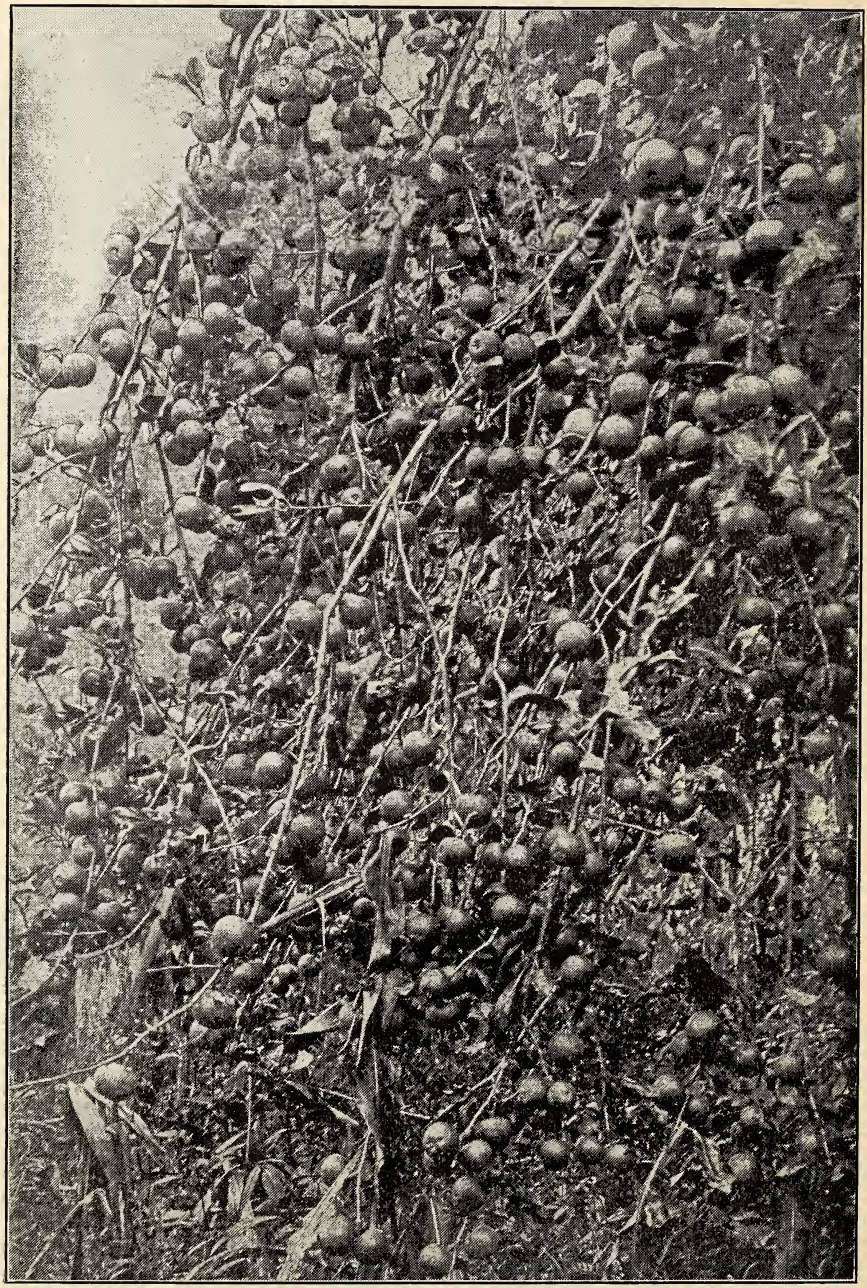
Rall's Genet (Janet, Neverfail) is of medium size, oblate, conical form, yellow and red striped, of mild flavor, and of very good quality. Ripens very late, is a good keeper, and ships well. It grows very well in the mountain counties, and is a good market apple. Originated in France.



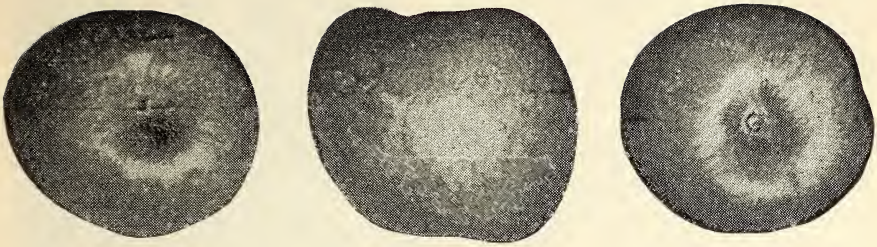
Winesap.

Winesap.—This is one of the well known and highly appreciated apples which thrive to perfection in the upper Piedmont and mountain counties. It is round, oblong, red, with indistinct yellowish striping, acid flavor, of very good quality, and ripens late. It is a good keeper, and bears shipping well; is esteemed for dessert, kitchen and market. One of the apples for western North Carolina.

York Imperial (Johnson's Fine Winter) is of medium size, oblate, irregular form, yellow and red in color, indistinct stripes



Red Limbertwig.



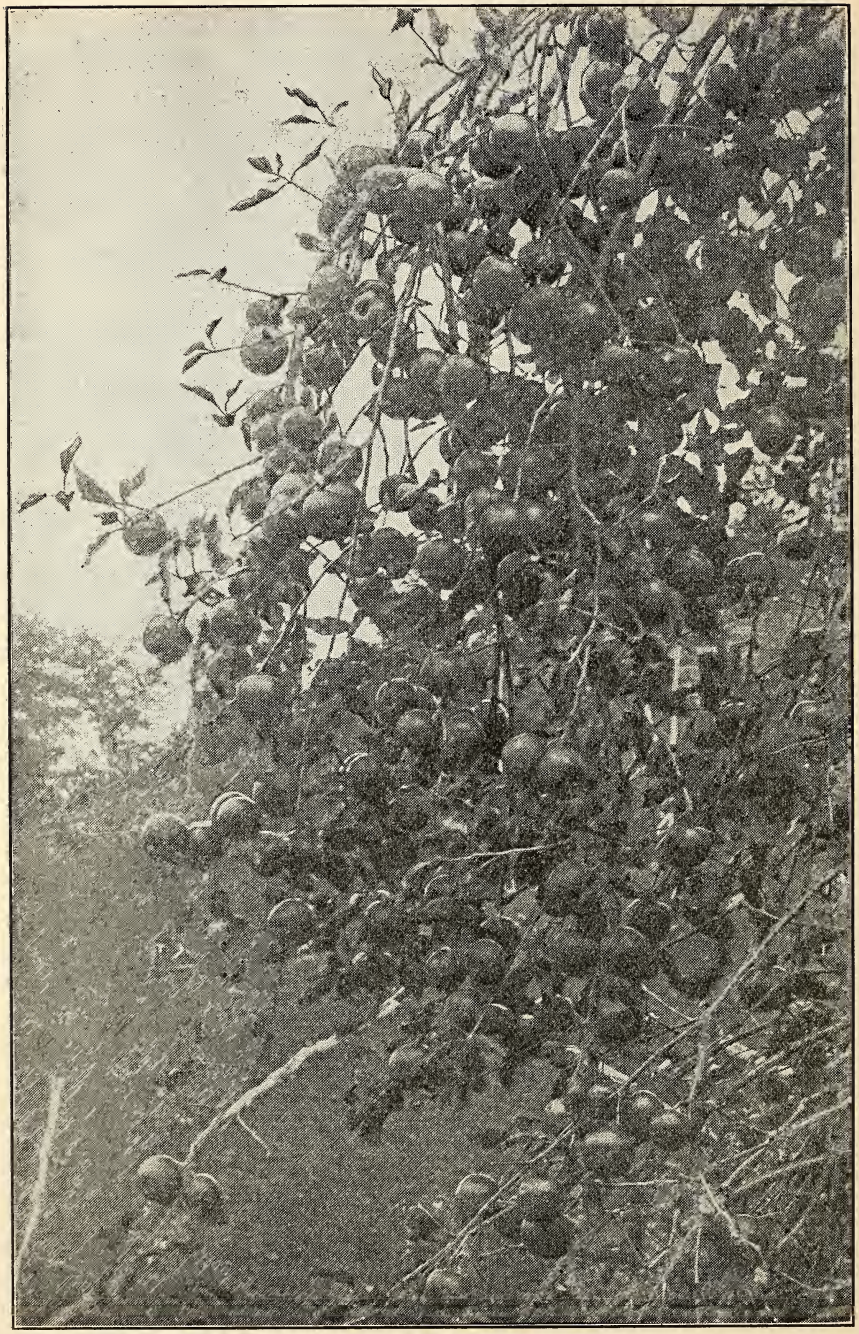
York Imperial.

sometimes mild in flavor, very good quality. Ripens late, and an all winter keeper. Much esteemed as dessert and market apple. It grows to great perfection in the western counties of the State, bears shipping well, and is recommended as one of the best for winter market.

Varieties for Central and East Carolina.

In all that vast territory lying east of the Blue Ridge and of the Brushy and South Mountains, and generally described as the Piedmont plateau, and even to the eastward of this, certain apples may be profitably grown for family use and for nearby markets. With this in view the list below is confidently submitted for the consideration of those interested in the growing of tree fruits in the middle and eastern counties:

Bonum,
Buckingham,
Bullock,
Carolina Beauty,
Cotton (early),
Early Strawberry,
Edwards,
Hoover,
Horse,
Kinnard,
Mattamuskeet,
McCullers,
Mother,
Pine Stump,
Romanite (South),
Red Astrachan,
Red June,
Shockley,
Virginia Beauty,
White Juneating,
Winesap,
Yellow Transparent.



Cheese Apple.

III. PREPARING APPLES FOR MARKET.

This, next to the growing, is the most important work connected with the apple business; it is necessary therefore to emphasize the fact that the *sorting* and *packing* in proper barrels is worth as much money to the grower as the fruit itself, *i. e.,* properly sorted and packed fruit is worth *twice as much* on the market as the same fruit sent in open wagon-beds and unsorted. That being true, no one is excusable for deliberately throwing away one-half the value of his crop of apples.

Fig. 1. How not to ship Apples.

Hence is shown in Fig. 1 a crate of apples; it is not quite full, and there is no means of filling it so that the fruit will not jostle, rub and bruise in transit. This Fig. 1 shows how not to pack fruit. Apples sent in such packages arrive in bad condition, and there is a loss of from one peck to three pecks in all such crates, and the price is affected adversely. The shipper raises a howl, and blames the commission merchant, the railroads, and everyone except *himself;* not realizing that it is his *neglect,* and that no market can pay full market value for fruit so treated.

Figure 2 shows an inexpensive and simple device, which can be made on any farm. It is very useful in properly securing the fruit and head in an apple barrel. A 2 by 8-inch timber 8 or 10 feet long has a chain fastened near one end. At the other end of the chain (which should be a little shorter than the height of the barrel) attach a sound 2 by 4-inch beam of about same length as the bottom piece. Place the barrel on the bottom timber when ready to head, and then put the head pieces in place; on these set a block of wood large enough to bridge over the pieces of the barrel head, then pull down on the beam slowly, tapping the head in place and fasten with cleats and nails.

Of course, everyone knows that the fruit must more than fill the barrel by two or three inches, and be *forced* into place with a steady pressure, the object being to give all the fruit in the package a little pressure to hold it in place, so that in transit it will not *move.* This is essential. Do not be afraid of making cider out of the fruit, but apply pressure enough to hold the fruit firmly in place. If this is not done injury to the quality of the fruit will certainly result.

Figure 3 shows a patented header. It is the handiest device yet found for heading barrels. The two arms are of iron, about size of buggy tire, and crooked at the ends to catch the chine at the bottom of the barrel, when the block is set across the pieces of the head and the pressure is applied by the screw above. The device enables one man to head a barrel, and he does it with rapidity and ease.

FIG. 2. Inexpensive method of compressing the fruit in barrels.

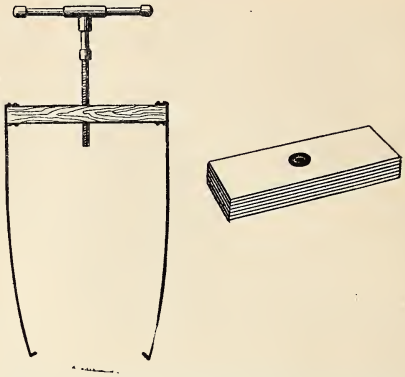


FIG. 3. A valuable patented device for handling barrels. The handiest method.

As a last admonition, let us urge the observance of the suggestions above in sorting and filling the barrels. All of this is troublesome, some will say. That is true, but as it doubles the price of the commodity you offer for sale, is it not the truest economy? Does it not make you two dollars for the one you have been getting before? Is it not worth while? Try it and see.

Ben Davis.

IV. HOW TO UTILIZE THE SURPLUS APPLE CROP.

By GERALD McCARTHY, Biologist, Department of Agriculture.

Dried and Evaporated Apples.

The annual production of apples in North Carolina is about 7,000,000 bushels. A large proportion of this output is from seedling trees, and from varieties of local origin, which are not called for by the general market.

The more important apple growing counties of North Carolina are as yet poorly supplied with railroad facilities, which makes it all the more difficult to market the fruit in the fresh state. As a consequence, there is a very large waste. North Carolina produces an immense quantity of hand-peeled, sun-dried apples, which sells in the market at a price which scarcely covers the cost of labor involved, to say nothing of the fruit itself. The labor cost of producing sun-dried apples is about 2½ cents per pound. The selling price is 3 to 3½ cents. The estimated output is 10,000,000 pounds annually.

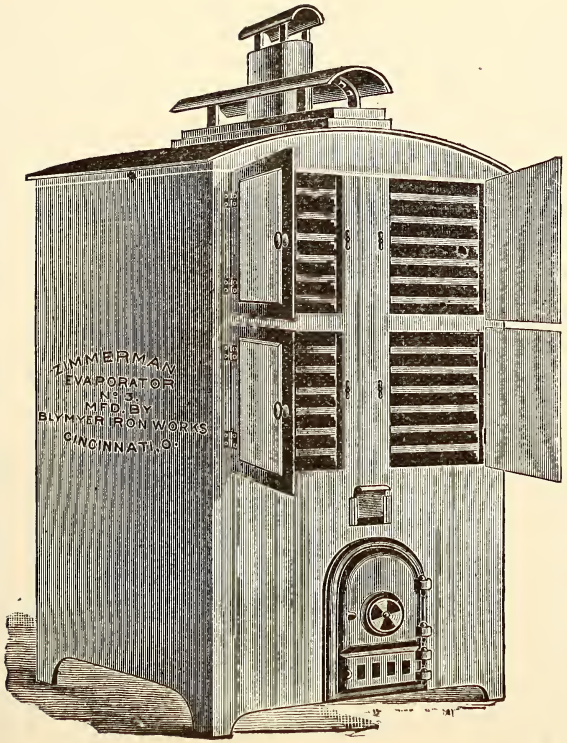
On the other hand, fruit evaporated by modern, improved methods and apparatus costs about the same as for the sun-dried product; but while sun-dried apples bring only 2½ to 3½ cents per pound, evaporated apples command 6 cents. At the latter price the North Carolina crop, estimated at 10,000,000 pounds, would net a profit of $300,000 per year.

The possibilities for expansion in apple growing in North Carolina are almost unlimited. When a fair profit is assured, as it must be by the general introduction of improved evaporators, and modern methods for utilizing the lower grades of fruit, we may look for a great increase in orcharding, and as a result, greater prosperity for the mountain region, where our best apples are grown.

The experience of practical apple-growers in the Northern States seems to show that on a commercial scale no evaporator will pay which turns out in a day's run of ten hours less than 300 pounds of dried fruit. In practice it is customary to keep the evaporator going night and day during the season.

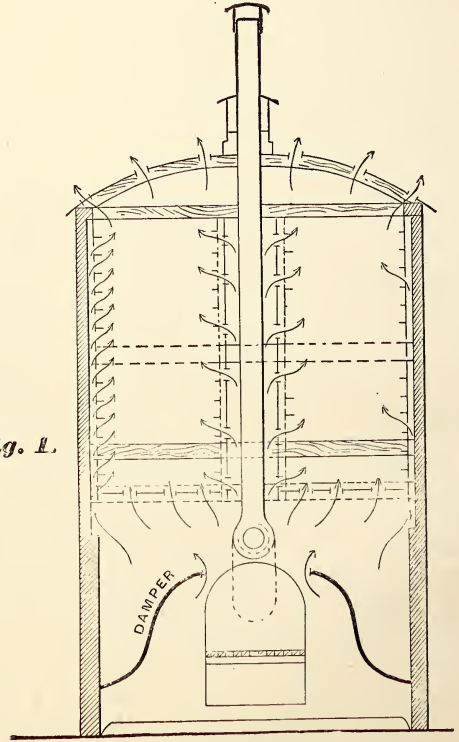
One of the best evaporators for farm use is the Zimmerman, made by the Blymer Iron Works Co., Cincinnati, O. This machine is built entirely of metal, and is therefore fire-proof. There are several styles on the market, differing mainly in size, but no one who evaporates for the market should buy a smaller machine than the No. 3, which consumes about twenty bushels of fresh fruit in ten hours. This machine costs about $100. The No. 4 will work up 30 to 40 bushels in ten hours, and costs about $170.

In all commercial evaporators the fruit is peeled, cored, and sliced



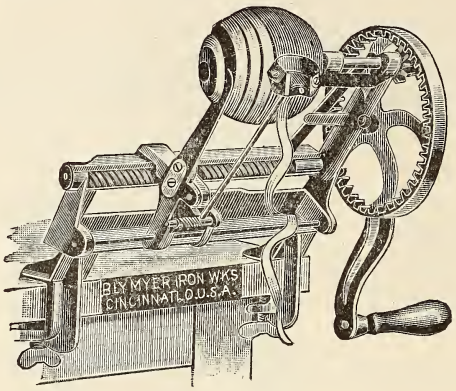
Zimmerman Evaporator.

Fig. 1.



Zimmerman Evaporator—Sectional View.

at one operation, by a machine which may be run by hand, water or steam power. The Bay State parer, sold by the Blymer Co., is one of the best of these. This costs, in factory size, $3.50. With this machine, and two boys to trim or cut out specks, one man can pare from 30 to 40 bushels of fruit per day.



Bay State Parer.

In large factories it is customary to bleach the fruit after peeling, by submitting it to fumes of burning sulphur. But such fruit is not so wholesome nor palatable as that unsulphured. If the fruit is dropped into a tub of weak salt brine as soon as sliced it will not discolor, and while retaining all the natural flavor of the apple, will appear in the dried state nearly as white as the sulphur-bleached fruit. The brine is made by boiling for ten minutes one pound of clean table salt in 16 gallons of water. Carefully skim off the scum which rises, and allow the water to cool before using. The fruit is simply dropped into the salt bath and allowed to soak about five minutes. It is then removed, drained for a few minutes and placed in the evaporating trays. The salt does not taste upon the finished product. A fresh bath should be provided every four hours.

The trays upon which the fruit is placed are bottomed with galvanized iron wire. The fruit is placed upon these in a thin layer. Wood is always used as fuel in the portable evaporators. The length of time required to dry the fruit differs with the different varieties of fruit, and with the temperature and other factors, which can be determined only by practical experience. The fruit is properly dried when it does not show moisture when broken. It must not, however, become so dry that it will snap or crackle when broken between the fingers. After removing from the evaporator the fruit is piled on a clean floor three or four feet deep, and allowed to sweat for several days. It is then ready to be boxed. The best grade is always sent to market in new boxes, lined with white paper. Cheaper

grades are marketed in new barrels. The cores and parings may be dried and packed in barrels. There is a large demand for this grade for manufacturing into jelly. But as a rule the North Carolina farmer can make more by fermenting the cores and parings and making vinegar out of them.

Apples which are too small to evaporate can be profitably worked into other merchantable products.

Apple-Butter and Marmalade.

There is a good local demand for these products. In making apple-butter and marmalade the fruit, without paring, is sliced or chopped, and boiled until soft in an old fashioned heavy, iron kettle. Place the chopped fruit in the cooker, and cover with juice of same fruit. Plain water will do, but this entails more work in evaporating the water. Boil until the fruit becomes soft enough to be easily run through a colander or seive. Pass through colander to remove seeds, skins, and cores. Add sugar to taste. The amount of sugar required depends upon the variety, natural sweetness, and ripeness of the fruit used, and also upon the judgment of the operator, and the demands of his trade. Usually in making apple marmalade, to every 100 pounds of apple paste from the colander 30 pounds of sugar is added. Cook again until the marmalade is reduced to the desired constituency. Usually 100 pounds fruit and 8 gallons fruit juice, to which is added 30 pounds granulated sugar make 110 pounds finished marmalade.

Fruit butter differs from marmalade only in being spiced, and using only 20 pounds sugar to 100 pounds fruit. Both these products keep well in ordinary covered wooden pails, if kept in a cool, dark place. The best marmalade is made from crabs.

Jelly.

Pure fruit jellies have become scarce and high priced on the market. The preparation of jellies can be profitably carried on in connection with canning fruits. Fruit too ripe for canning can be utilized for jelly making. The fruits best suited for jelly making are apple, pear, peach and plum. The currant also makes fine jelly.

To make jelly, only sound, fully ripe fruit may be used. Apples and pears are first grated, and then crushed in a press, preferably of the hydraulic type. The juice as it runs from the press is filtered through a horse-hair sieve, or a layer of finely chopped and well washed oat or rye straw. Sugar enough—ordinary granulated sugar is best—is added to bring the density of the juice up to twenty degrees on the saccharometer. The sweetened juice is then at once run into the boiling pan. The ordinary pan used in boiling sorghum or maple sap for syrup is equally suited for jelly making. But

a better grade of syrup and jelly can be made in a pan or boiler which excludes the air and prevents the formation of caramel. The best form of pan is a long covered and ventilated wooden trough, having heavy copper steam pipes running lengthwise of the box. The steam in the pipes must be under a pressure of not less than eighty pounds. The South Allen Evaporator, made at Mt. Gilead, O., is of this type, and gives good satisfaction. Whichever pan is used, the heating surface must be hot enough to keep the juice boiling vigorously from start to finish. The scum thrown up by the boiling juice must be carefully skimmed off. Not more than eight minutes boiling should be required. Longer boiling darkens the product, and also reduces its sweetness. The degree of condensation required to jellify differs with different fruits. Usually, in making apple jelly, five parts of juice make one of jelly. To one hundred pounds of clear juice is added about twenty pounds of sugar. The product is forty pounds of sweetened jelly. This can be sold at a handsome profit.

Fruit Juices.

There is considerable demand for plain fruit juices. These are used for making the syrups used in soda water and for various other purposes. In making apple, pear and quince juice, the fruit is crushed and pressed as described for apple jelly. The juice, as it runs from the mill, is filtered through finely chopped and well washed rye straw. It is then clarified by adding the white of two eggs for each gallon of juice. The egg should be beaten up thoroughly with a small quantity of juice, and this stirred into the whole. Then heat to about 200 degrees F. Allow to stand for two hours, and siphon off the clear liquid into heavy opaque glass or earthen bottles, which must not be completely filled. Place the bottled juice in cold water bath, and heat until water in the bath begins to boil. Then seal bottle air tight, withdraw the fire, and allow bottle to remain in bath until water is cold. Store juice in a cool, dark place.

V. CIDER VINEGAR.

By GERALD McCARTHY, Biologist, N. C. Dept. Agriculture.

Vinegar made from pure cider or grape wine is the best and most wholesome form of this popular condiment.

The fabrication of pure cider vinegar is a very simple process, and one which any one who can grow or buy a few bushels of apples may successfully carry on.

In the production of pure cider vinegar, four factors are concerned. These are:

1. Pure cider.
2. The presence of the acetic acid ferment, *Bacillus aceti.*
3. Free ingress of air.
4. Temperature of the air or room not less than 70 degrees, nor more than 85 degrees F.

As vinegar is ordinarily made on the farm, it is simply allowed to ferment spontaneously in unbunged barrels in a cellar whose temperature during the fall months when cider is usually made is pretty constant at about 60 degrees F. The acetic acid ferment does not grow actively at any temperature below 70 degrees F. Hence the relatively long period it requires to produce good vinegar in farm cellars. Although the acetic ferment requires a comparatively high temperature, there are many other ferments which can grow at lower temperatures. These generally get into the farmer's vinegar barrels and make trouble. The following described process will enable any one to make a fine vinegar with the least possible waste of time and material.

Take sound barrels or any suitably sized vessels of wood, earthen ware or glass—never iron, copper or tin. Clean thoroughly and scald. Fill not more than one-half full with the cider stock, which should have fermented at least one month. To this add one-fourth its volume of old vinegar. This is a very necessary part of the process, since the vinegar restrains the growth of chance ferments which abound in the air, and at the same time it favors the true acetic acid ferment. Next add to the liquid a little "mother of vinegar." If this latter is not at hand, a fairly pure culture may be made by exposing in a shallow uncovered crock or wooden pail a mixture of one-half old vinegar and one-half hard cider. The room where this is exposed should have a temperature of about 80 degrees F. In three or four days the surface should become covered with a gelatinous pellicle or cap. This is the "mother of vinegar." A little of this carefully removed with a wooden spoon or a stick should be laid gently upon the surface of the cider prepared as above described.

Do not stir it in. The vinegar ferment grows only at the surface. In three days the cap should have spread entirely over the fermenting cider. Do not break this cap thereafter so long as the fermentation continues. If the temperature is right, the fermentation should be completed in from four to six weeks. The vinegar should then be drawn off, strained through thick white flannel, and corked or bunged tightly and kept in a cool place until wanted for consumption. If the vinegar remains turbid after ten days, stir into a barrel one pint of a solution of one-half pound of isinglass in one quart of water. As soon as settled, rack off and store in tight vessels. Usually no fining of vinegar is needed. No pure cider vinegar will keep long in vessels exposed to the air at a temperature above 60 degrees F. "Vinegar eels" are sometimes troublesome in vinegar barrels. To remove these, heat the vinegar scalding hot, but do not boil. When cool, strain through clean flannel and the "eels" will be removed.

In making cider vinegar, the strength of the product or per cent by weight of the acetic acid in it, will be a little less than the per cent by weight of the alcohol in the cider. A little of the alcohol remains unfermented, and serves to give the desired flavor or boquet to the vinegar.

There is another and even more rapid method of making cider vinegar. In this method, the fermented cider, or "hard cider," is run through a box of beech-wood shavings, wetted with old vinegar. By this method, good vinegar may be made in twenty-four hours. But the process described above makes better vinegar, and is on many accounts preferable for farm use.

Bulletin No. 183 April, 1903

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

INSECT AND FUNGUS ENEMIES OF THE APPLE, PEAR AND QUINCE, WITH METHODS OF TREATMENT.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

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Insect and Fungus Enemies of the Apple, Pear, and Quince, with Methods of Treatment.

By F. L. STEVENS, Biologist, and FRANKLIN SHERMAN, Jr., Entomologist.

I. INSECT ENEMIES.

By FRANKLIN SHERMAN, Jr., Entomologist.

a. INSECT ENEMIES OF THE APPLE.

The apple is attacked by a greater variety of insect pests than any other of our cultivated plants, and in this discussion we have only considered the more serious of these, believing that by thus simplifying the discussion it will be more useful.

In the chapter on spraying we have shown (pages 42-43) that an apple orchard should be sprayed at least three times every spring, with Bordeaux mixture and Paris green. By such treatment several of the pests here discussed will be held in check. Therefore, in the consideration of those particular insects we have usually, under the head of "remedies," merely referred to the chapter on spraying where the treatment is described.

The insects here discussed may be conveniently divided into four groups, the discussion of each of which begins on the page indicated.

1. Insects Attacking the Roots (see below).
2. Insects Attacking the Trunk and Branches, page 53.
3. Insects Attacking Leaves and Tender Shoots, page 54.
4. Insects Attacking the Fruit, page 64.

1. Insects Attacking the Roots.

There is only one insect that commonly does damage by attacking the roots of apple:

THE WOOLLY APHIS. (Fig. 1.)
Schizaneura lanigura, Hausm.

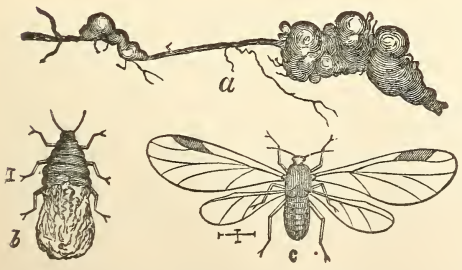

Fig. 1.—The Woolly Aphis.
a, Root knotted by the insect. *b*, Normal wingless form of louse. *c*, Winged form of louse.
(From Lippincott Co.)

General Description.—Small insects covered with a whitish wool, living in colonies on the roots, where they cause knotty, gall-like swellings. When crushed they give a reddish stain.

Life-history and Habits.—The woolly Aphis is illustrated in Fig. 1, where the insects are shown very much enlarged at *b* and *c*, while a gall on a root is shown nat-

ural size at *a*. The galls are often larger, and on larger roots than here shown. The louse commonly found on the roots is wingless, as shown at *b*, but there may be winged individuals, as shown at *c*.

The full life-history of the insect is not understood. It attacks both the roots and the branches of the apple, but is more destructive when on the roots. It apparently thrives throughout North Carolina, as it has been reported from various localities from Wayne to Haywood counties. When it becomes established on a young tree it is likely to be serious, but if a tree does not become infested until it is fully grown the results are not likely to be serious.

Remedies.—Nurserymen should avoid shipping trees that are affected with this louse. Such affected trees work harm to the trade. Trees with knotted roots should be discarded both by nurserymen and growers. It is difficult to treat growing trees that are affected. The best that can be done is to dig away the earth at the base of the trees so as to expose the infested roots, thoroughly sprinkle them with tobacco dust, and replace the earth.

2. Insects Attacking the Trunk and Branches.

Under this head we shall consider nine species of insects, the first four of which bore within the bark or wood, while the others remain exposed on the outside of the branches. It is evident that those insects which bore within the bark or wood are protected largely by the tree itself, and are therefore hard to combat, but the methods here given are the best that we have been able to find.

The Round-headed Apple-tree Borer. (Fig. 2.)

Saperda candida, Fab.

General Description.—A white grub, attaining a length of a little more than an inch, which bores into the trunk at the surface of the ground, often girdling and killing the tree. The grub has hard, strong, black jaws. The head end of the body is somewhat enlarged, but is not especially broad and flattened. (See Fig. 2 *a*.)

Life-history and Habits.—This borer is probably present in greater or less numbers throughout our State, but so far as yet recorded its serious injuries are confined to the western portion, where it often kills trees. The injury is marked by the yellowing, sickly leaves, which are sparsely developed on the tree.* The presence of the pest is also often indicated by discolored bark at base of tree, and the fine, brown, powder-like castings which are forced out through crevices in the bark.

*This indication must not be confused with the Apple Rust, a fungous disease which attacks the leaf. Trees which are attacked by rust will nevertheless put out a full set of leaves in the spring, while a tree badly attacked by the Round-headed Borer is unable to put forth a full set of leaves.

The grubs live for three years in the tree, but until about grown they confine themselves to the sap-wood. When grown they burrow into the solid wood, and then change to the *pupa,* (Fig. 2 *b*), which in two or three weeks develops to the adult beetle (Fig. 2 *c*). The beetles emerge in early summer, and during June, July and August the females deposit their eggs on the bark of the trees, when, their mission in life having been fulfilled, they die.

This insect attacks the wild crab-apple, pear, quince and mountain ash, but its injuries are most frequently noticed on the apple. The adult beetles are very beautiful insects but are not often seen, as they fly mostly at night.

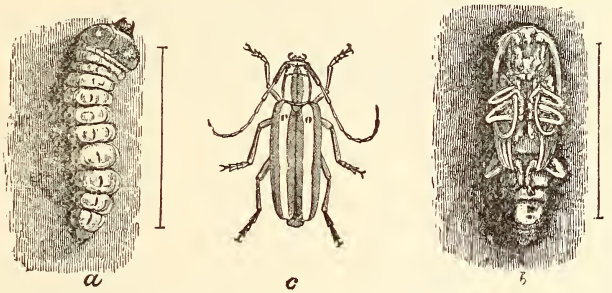

Fig. 2.—The Round-head Apple-borer.
a, grub; *b*, pupa; *c*, adult beetle.
(After Smith.)

Remedies.—A tree found to be infested by this borer should be examined carefully and the insects killed by digging into their burrows with a knife or probing them with a wire. In late winter the earth should be mounded against the base of the tree to a height of four or six inches, and this mound is removed in fall. The trees should be examined and the worms destroyed during the winter. This work should be kept up regularly every year.

A good means of protecting the trees consists in covering the base and lower portion of the trunk with wire mosquito-netting. This should be tied closely to the trunk at the top, but should not touch it below that point, and the bottom should be put below the surface by banking a little earth against it with a hoe. The netting need not extend more than fifteen or eighteen inches up the trunk and such a protection is quite inexpensive, as four or six pieces of sufficient size for young trees (three to eight years) can be cut from one square yard of netting. This does not give so perfect a protection as might be expected from it, but it is a great help. It is, moreover, an effectual protection against mice, rats, and rabbits, which often do considerable injury by gnawing the bark of young trees.

Still another useful method is to keep the bottom of the trunks smeared with tar during the egg-laying season (June and August), so that the beetles will lay their eggs on other trees.

There is really little need of trees being killed by this borer if the grower will carefully look after them as here described.

THE FLAT-HEADED APPLE-TREE BORER. (Fig. 3.)

Chrysobothris femorata, Fab.

General Description.—A white grub attaining a length of about an inch, with a very broad, flat head (see Fig. 3 *a*) which bores under the bark of the trunk and larger branches, causing the bark over the affected places to turn dark and dry. Sometimes they completely girdle the tree and cause its death.

Life-history and Habits.—The injury done by this insect is frequently attributed to "sun scald," but by cutting away the deadened bark, the grubs of the Flat-headed borer will often be found working in the inner bark and sap-wood.

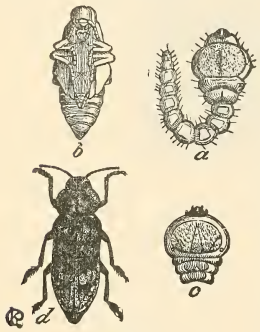

Fig. 3.
The Flat-headed Apple-borer. *a*, the grub; *b*, the pupa; *c*, head of grub enlarged; *d*, adult.
(After J. B. Smith.)

The Flat-headed borer is apparently much more numerous and destructive in the eastern part of our State than in the western, though it is no doubt present in all sections. There is evidently one complete brood each year in this State. The eggs are laid on the bark of the tree in summer, any time from June to September, in this State.* The little grubs that hatch from these eggs at once bore under the bark, where they feed and grow throughout the winter. When nearly grown they usually bore into the solid wood and then cut a passage to the outer bark, but not through it. Then they return to the depths of the burrow and change to the pupa (Fig. 3 *b*), and in the course of about three weeks the adult beetle emerges (Fig. 3 *d*), which proceeds to provide for another generation.

Remedies.—Like most insects which bore within the bark and wood of trees, this pest must be combatted by mechanical means, as the tree itself hides and protects it from direct remedies. The presence of the pest is usually easily detected by the discolored areas of bark under which it is working. It is then an easy matter to cut away the dead bark and kill whatever grubs are found. If this work necessitates the removal of a considerable amount of bark the wound may be helped by an application of paint or whitewash after the operation. The best seasons for this work is late winter, as the grubs are then usually of large size and easily found. Trees that

*Most published accounts state that "the eggs are laid in June," but I have taken the adult beetle June 12, and also took a healthy pupa on August 22, the same year. This was in middle North Carolina and shows that with our long seasons the adults are emerging from June to September.

are thus attended to regularly each year are not likely to become badly infested.

THE FRUIT BARK BEETLE. (Fig. 4.)

Scolytus rugulosus, Ratz.

General Description.—A small, black, hard-shell beetle, about one-eighth inch in length, which bores small holes through the bark of the trunk and branches, usually found in great numbers in infested trees. They eat out the sap-wood and finally kill the branches or entire tree.

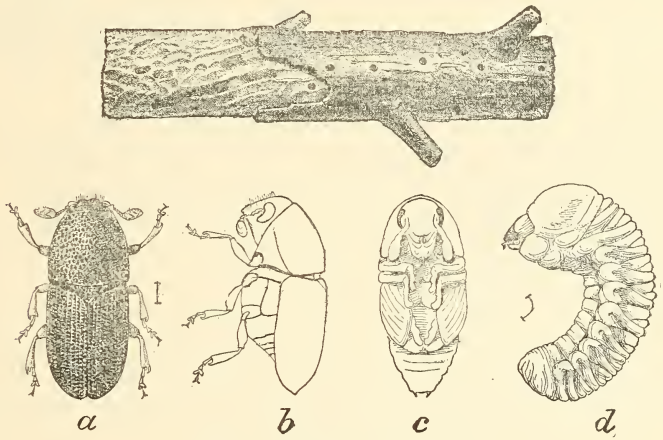

Fig. 4.—The Fruit Bark Beetle.
Above, piece of twig with bark removed to show sap-wood eaten away.
Blow stages of the insect—*a*, beetle; *b*, same; *c*, pupa; *d*, larva.
(After F. H. Chitten, U. S. Dept. Agr.)

Life-history and Habits.—Injury to trees by this insect usually indicates neglect on the part of the owner, for while they may attack healthy trees, they usually and by preference attack trees that have already been weakened by other causes. A tree badly injured by either of the pests before discussed, or from other causes, may be attacked by this Bark Beetle and speedily killed. So far as we have observed it does not attack apple so often as peach, cherry and plum, but injury to apples by no means uncommon, and specimens of apple bark riddled by the insect have been sent to us. The figure shows well the appearance of an infested branch, part of the bark of which has been removed to show how the sap-wood had been eaten out. The figure also shows the stages in the life of the insect. The adult beetles bore the little round holes through the bark and burrow through the sap-wood. Within these burrows the eggs are laid and the little grubs which hatch from them continue the work of destruction. The insect occurs throughout our State from the mountains to the coast.

Remedies.—If a badly infested tree is found in the midst of an otherwise healthy orchard, it is best to remove and burn it at once, so as to lessen the danger to other trees. As already indicated, the most important method of preventing injury by this pest is to keep the trees in sound, healthy condition, so that they will not be so much subject to attack. Orchards that are well cultivated, fertilized, pruned and sprayed are not apt to be troubled by this insect. It is the neglected orchards that suffer most; the well kept ones least. If an orchard has become badly infested, the worst branches should be cut out and burned and the other affected parts rubbed by hand with a rag saturated with pure kerosene.

THE WOOLLY APHIS. (Fig. 1.)

Schizaneura lanigura, Hausm.

General Description.—Colonies of soft-bodied, louse-like insects, covered with whitish wool, found on small twigs and tender shoots and at places where branches have been cut off in trimming.

Life-history and Habits.—This insect has already been discussed as attacking the roots, but as it also attacks the branches, will be briefly discussed here as to remedies.

Remedies.—Colonies of this insect may be readily destroyed by the application of kerosene emulsion at strength of 20 per cent, applied with a spray pump. (See Bulletin on Spraying.) It is common in orchards throughout the State, and we would not recommend the use of remedies save in instances where it is doing noticeable injury. In the chapter on Spraying will be found directions for preparing the kerosene emulsion and diluting it to the strength desired.

SCURFY SCALE-LOUSE. (Fig. 5.)

Chionaspis furfurus, Fitch.

General Description.—White scale-insects attached to trunk and branches of the apple, sometimes also found around the blossom end of fruit. When a tree is thickly infested it looks as if whitewashed. Scales about the size of large pinhead.

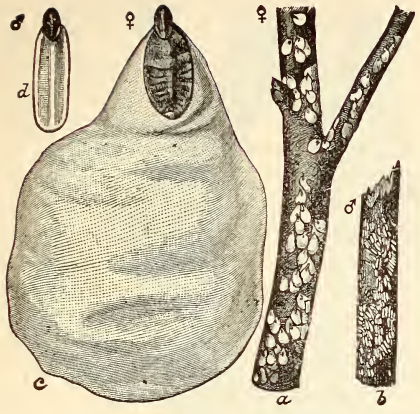

Fig. 5.—The Scurfy Scale-louse.
a, twig with female scales, natural size; *b*, twig with male scales, natural size; *c*, female scale much enlarged; *d*, male scale much enlarged.
(From U. S. Dept. Agr.)

Life-history and Habits.—The Scurfy Scale-louse is more abundant and destructive in the wester than the eastern part of the State. It is found on both pear and apple, but more frequently on the latter. The white scale-like object covers the body of the insect itself, which is reddish in color, and may be seen by carefully lifting one of scales with the point of a pin. The winter is passed in the egg state; the eggs, which are reddish in color, being found under the large scales. In the spring these hatch into tiny louse-like insects, which crawl over the bark for a few hours. Then they insert their beaks into the bark and begin to suck the sap. After once inserting the beak in the bark the insects remain attached at that spot, and the scale begins to form over the body.

Remedies.—Kerosene emulsion used as a spray at a strength of 25 per cent oil, is a very satisfactory remedy for this pest. (See Bulletin on Spraying.) In using the kerosene emulsion, only just enough should be used to thoroughly dampen all the bark of the tree, without letting it run down the trunk and in at the roots. The treatment for this insect should be applied only during the winter, when the leaves are off and the trees are in dormant condition, or when the buds first begin to swell in the spring. It is best to apply it during bright, dry weather, as it is then less likely to hurt the tree.

THE OYSTER-SHELL BARK LOUSE. (Fig. 6.)

Mytilaspis pomorum, Bouche.

General Description.—Brown scale insects which, in general, have the shape of an oyster shell, sometimes so numerous as to almost completely cover the bark. Scales about one-eighth inch long.

Life History and Habits.—This insect is much like the preceding in its life history, though the body of the insect is yellowish and the eggs which are found under the scales in winter are pearly white. The insect is seldom found on other fruits than the apple, and is mostly confined to the mountain counties, though it does considerable injury as far east as Newton, Catawba County.

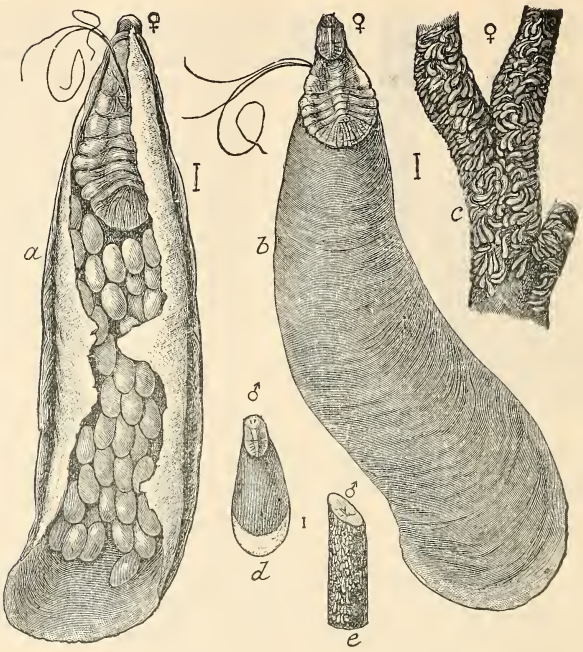

Fig. 6.—The Oyster-shell Bark Louse.
a, female scale from beneath showing eggs enlarged; *b*, same from above, enlarged; *c*, twig infested with female scales, natural size; *d*, male scale, enlarged; *e*, twig infested with male scales, natural size.
(From U.S. Dept. Agr.)

Remedies.—Kerosene emulsion at strength of 25 per cent oil will be found a very satisfactory remedy. (See Bulletin on Spraying.) Care must be taken to use no more emulsion than necessary to thoroughly dampen all the bark of the trunk and branches, without letting it run down the trunk and in at the roots. This should be applied during the winter, or when the buds first begin to swell in the spring. It is better to apply it during bright, dry weather, as it is then less likely to hurt the tree.

THE SAN JOSÉ SCALE LOUSE. (Fig. 7.)

Aspidiotus perniciosus, Comstock.

General Description.—A small grayish scale louse, about the size of a pinhead, often so numerous on trunk and branches as to completely cover the bark, making it look as if dusted over with ashes.

Life-history and Habits.—This is a very destructive scale louse, which attacks practically all of our fruit trees except Keifer, Garber and Leconte pears. If neglected it will almost certainly ruin an orchard. Fig. 7 shows the appearance of twigs infested by this insect, natural size at *a* and enlarged at *b*. Each of the little scales covers the

body of a tiny insect beneath it, which has its beak inserted in the bark sucking the sap. Badly infested trees become so coated over with scales that they look as if dusted with ashes. This, like the other scale lice discussed, is largely spread by means of infested trees being shipped from place to place. In orchards the young lice may be carried from tree to tree upon the feet and feathers of birds, or by other insects. They may also be borne by the wind, as they are very small and may be blown about like dust. This insect has been located in various parts of the State, so that no section can claim to be exempt.

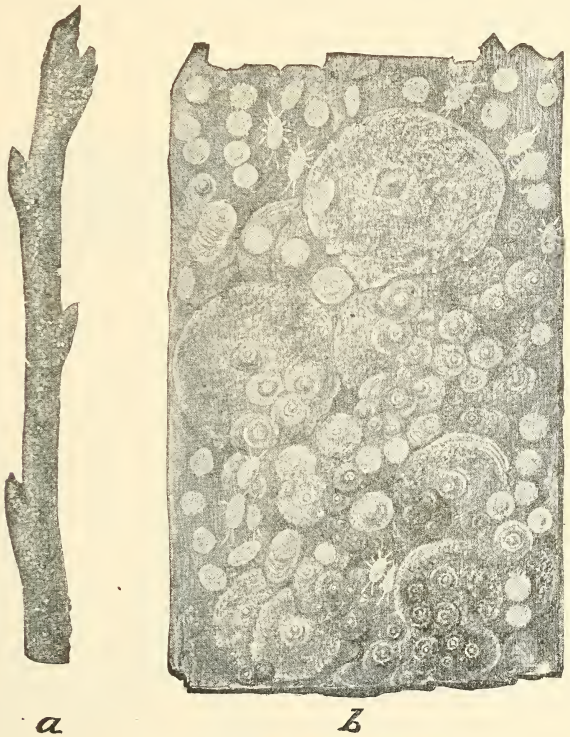

Fig. 7.—The San Jose Scale-louse.
a, appearance of badly infested twig, natural size; *b*, same enlarged.
(After Howard & Marlatt, Bul. No. 3, U. S. Div. Ent. Dept. Agr.)

Remedies.—Apple trees infested with this pest should be sprayed at least once each winter with kerosene emulsion at strength of 25 per cent oil. (See Bulletin on Spraying.) This should be done during the winter, while the leaves are off and the trees are dormant, or when the buds are first swelling in spring. Care must be taken to use no more of the emulsion than is necessary to thoroughly dampen all the bark, without allowing it to run down the trunk and in at the roots. If continued experience shows that the scale continues to be a serious menace, when the trees are thus treated, and the trees do not

seem to be hurt by the treatment, the emulsion may be used at 30, 40 or even 50 per cent oil, but it must be remembered that oil is fatal to plants if too much is used, and the emulsion should not be used stronger than is necessary to secure good results. It is best to apply it during bright, dry weather, as it is then less likely to hurt the tree.

3. Insects Attacking the Leaves and Tender Twigs.

Scale Insects.—All three of the scale lice just discussed may be found on the leaves and tender twigs of the apple, but as they are more abundantly found on the trunk and branches, they have been already described under that head.

THE GREEN APPLE APHIS.

Aphis mali, Fabr.

General Description.—Very small, green, soft-bodied insects, often found in great numbers on the tender twigs and leaves of apple. On badly infested trees the leaves assume a blackish appearance.

Life-history and Habits.—The Green Apple Aphis is found throughout the State, and is most destructive during warm wet seasons. It is usually more abundant and destructive in spring and early summer. Eggs laid in the fall pass the winter and hatch in the spring to females, which give birth to young. The insects increase very rapidly. Near the hinder part of the body are two little tubes through which a sweetish substance is passed. Ants are fond of the substance, and a tree that is infested by these lice is usually frequented by ants. This substance, falling upon the leaves, furnishes food for a kind of fungous growth, which gives them the blackish appearance.

Remedies.—This insect is present in almost all orchards every spring, and does not usually do serious injury. When it does, however, it may be readily checked by one or two prompt sprayings with kerosene emulsion with strength of 15 per cent oil. (See Bulletin on Spraying.) Use no more of the emulsion than is necessary to thoroughly wet the lice.

CANKER WORMS (2 species).

General Description.—Gray caterpillars which move with a looping motion ("measuring worms"), and which do not spin nests of web in the trees. They devour the leaves.

Life-history and Habits.—There are two species of canker worms which are often destructive in apple orchards in the Northern States. Although neither of these has done injury in North Carolina in the last three years so far as the writer can learn, yet it is recorded that they are frequently destructive, especially in the middle portion of the State.

Remedies.—Trees sprayed regularly three times every spring with the Bordeaux mixture and Paris green, as recommended in the chapter on Spraying, will not be troubled by canker worms, as the Paris green is fatal to them.

THE TENT CATERPILLAR. (Fig. 8.)

Clisiocampa americana, Harris.

General Description.—Caterpillars living in colonies and making large web nests in the trees, appearing usually as soon as the buds open in spring. Caterpillar attains a length of two inches or more, and is of a brownish color with a white stripe down the middle of the back, and markings of blue on the sides. The caterpillars leave the nest when they wish to feed and wander about in search of succulent leaves.

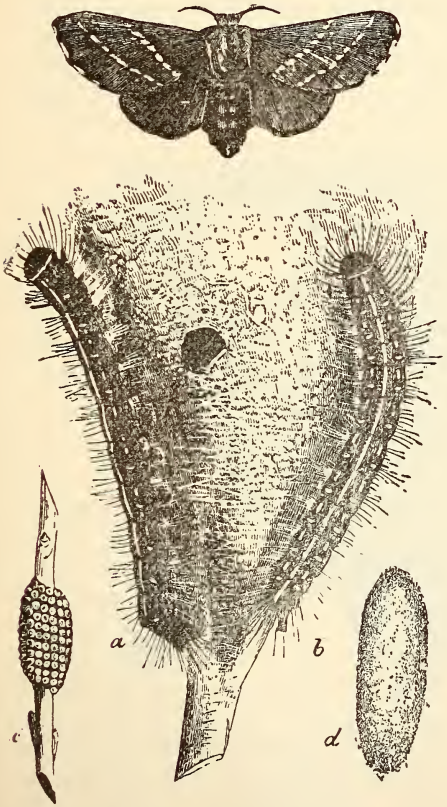

Fig. 8.—The Tent Caterpillar.
Above, adult moth; *a* and *b*, caterpillars; *c*, mass of eggs on twig; *d*, cocoon, which contains the pupa.
(After J. B. Smith.)

Life-history and Habits.—The parent insect of this caterpillar is a brownish moth, as shown at the top of Fig. 8. These moths lay the eggs during the summer, depositing them in masses on the twigs, as shown at *c* in the figure. The mass of eggs is covered over with a substance resembling glue, which protects them from cold and wet. The little caterpillars become fully formed in the eggs in the fall, but do not hatch out until the warm weather of spring when the leaves are starting. All the caterpillars from one mass of eggs form a colony and spin a web nest which serves as a shelter. As they grow, the nest is enlarged. When hungry, the caterpillars leave the nest and wander about in search of apple leaves, and this habit distinguishes this species at once from the Fall Web-worm, next described. When fully grown, the caterpillars seek a sheltered place, usually in grass or rubbish on the ground, and spin about themselves soft silken *cocoons* (Fig. 8 *d*), within which

they change to what is known as the *pupa*. In course of two or three weeks, the pupa develops to the adult moth, which lays eggs for another brood and dies. A peculiar feature about this insect is that the adult moth has no organs for taking or digesting food; the sole object of reaching the adult condition being to provide for the next generation.

Remedies.—Farmers and farmers' wives go to considerable trouble over this insect every year. The ordinary method is to burn the nests any time during the day or evening. Some simply destroy the nests by means of twisting them up with a branched stick. By such means the home of the insects is temporarily destroyed, but those caterpillars, which are out feeding upon the leaves when the nest is destroyed simply set about to repair the damage when they return. The method is therefore only partially effective, and many nests are out of reach. The simplest and most effectual treatment is to give the trees three regular sprayings every spring with Bordeaux mixture and Paris green, as described in the Bulletin on Spraying, thus not only poisoning the leaves so that they will kill caterpillars, but also protecting the trees from numerous other enemies at the same time.

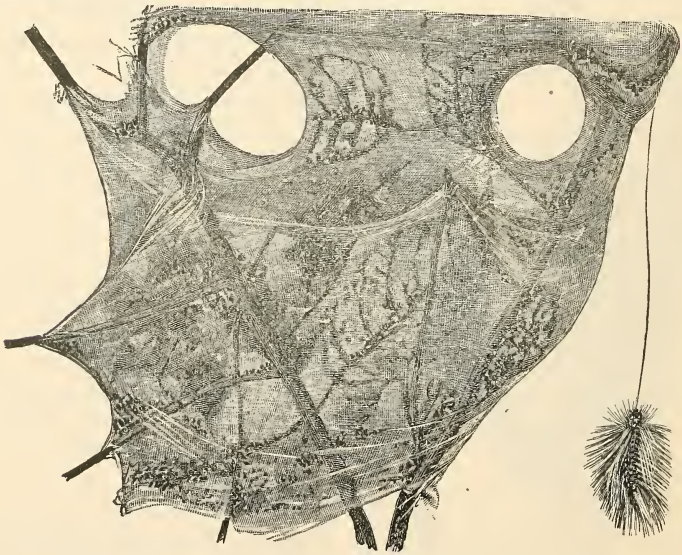

Fig. 9.—The Fall Web-worm,
Showing nest with caterpillar suspended by thread of silk at one side.
(After Howard, U. S. Dept. Agr.)

THE FALL WEB-WORM. (Fig. 9.)

Hyphantria cunea, Harris.

General Description.—Caterpillars living in colonies and making web nests in trees of apple, pear, elm, persimmon and others, the

nests usually appearing in June and later, *not in early spring.* The caterpillars attain a length of one inch, and are whitish in color, with a considerable covering of hair.

Life-history and Habits.—This species is often confused with the preceding, but is easily distinguished from it by three facts: 1st, the nests appear later in the season; 2d, the caterpillars are whitish, with considerable covering of hair; 3d, the caterpillars do not habitually leave the nest to feed, but as the leaves in the nest are devoured, the nest is enlarged to include new leaves for food. However, when fully grown the caterpillars do leave the nest and wander aimlessly about, feeding on various plants for a few days before they spin their cocoons. Fig. 9 shows a nest of this species with one of the caterpillars suspended by a silken web near it.

Remedies.—Orchards which are given the three regular sprayings every spring with Bordeaux mixture and Paris green, as described on page .. in the Bulletin on Spraying, are not much troubled by this insect; therefore, if such treatment is carried out, no other measures will be necessary. Otherwise the nests may be easily removed.

4. Insects Attacking the Fruit.

Scale Insects.—All three of the species of scale insects described may be found on the fruit, but have already been treated of under the head of Insects Attacking the Trunk and Branches.

There are two species of insects which are quite destructive to the fruit of the apple in this State; the Coddling Moth and Curculio, the first of which can be very largely controlled by Spraying, and the second only partially so.

The codling moth. (Fig. 10.)

Carpocapsa pomonella, Linn.

General Description.—White or pinkish colored "worms" found in the fruit of the apple, and sometimes pear, causing them to grow knotty, drop early, and rot badly, frequently eating out almost the entire core of the apple. The worm escapes through a hole in the side of the fruit.

Life-history and Habits.—This insect has had more to do with the decline of apple growing in eastern and middle North Carolina than any other one factor. "Wormy apples" are nothing more than apples infested by this insect, and what is known as "June drop" of apples is due largely to the same cause. A great many of the apples which rot in cellars are those which were first infested by this insect. The knotty, wormy, tasteless, worthless fruits produced by our eastern apple orchards bears testimony to its injuries where not combatted, whereas the smoother, more perfect fruits produced by sprayed trees,

shows the efficacy of this operation in its control. Two years ago, when the writer first began to advise spraying to the growers in the State, it seemed advisable to thoroughly test the matter to see if it would be as efficient here as it has been elsewhere. Experiments made by growers themselves, acting under our advice, has only given additional proof that good apples can be grown if the trees are sprayed, and, on the other hand, that they seldom can be grown otherwise. The insect occurs throughout the State, but, as already indicated, is more destructive in the eastern and middle sections.

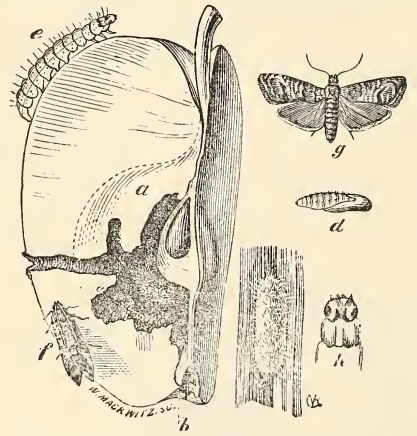

Fig. 10.—The Codling Moth.
a, apple cut to show borings of larva; *b*, place where egg was laid and larva started; *d*, pupa; *e*, larva; *f*, *g*, adult moths at rest and with wings spread; *h*, head of larva enlarged; *i*, cocoon.
(From Lippincott Co.)

The eggs are laid in the spring on the young apples, about the time that the blooms drop or a little later. In a week these hatch to tiny caterpillars, which crawl around to the *blossom end of the fruit* (almost invariably), and there eat their way into the core. Here the caterpillar feeds until grown, when it eats its way out through the side of the fruit, and makes its way to some secluded place to spin its cocoon. In this cocoon the caterpillar changes to a pupa (Fig. 10 *d*), which in a couple of weeks develops to the parent moth (Fig. 10 *f* and *g*), which lays eggs for another brood and dies.

We have stated that the caterpillars almost invariably enter the fruit at the blossom end. This applies especially to those that are hatched in the spring, for those of the second brood, which hatch in summer, are not so particular, and may enter the fruit at the side, in which case the spraying is not so likely to kill them. They pass the winter in various stages of existence and in various places. We have found fully grown caterpillars under loose pieces of the bark on the trunk of apple trees. Many pass the winter in stored apples. Cocoons may be spun in barrels or boxes used for shipping fruit, and the insects pass the winter in them in the pupa stage.

Remedies.—Among the many reasons for spraying, this pest is one of the greatest. Repeated tests in almost every State of the Union have only strengthened this statement. Our North Carolina growers who have carefully tested the matter, have found that their fruits are not nearly so badly infested by this worm on the trees which are sprayed as on those trees not sprayed. In the chapter on Spraying

three sprayings are recommended to be applied each spring, and of these the one which is given just after the blossoms fall does most to control this pest, as the poison is then lodged in the blossom end of the young apples, where it is eaten by the young caterpillars when they start to enter the fruit, thus killing them before they begin their destructive work.

This does not render the fruit at all unfit for use, as the poison is applied in such minute quantity. Further than this, the poison on the sides of the fruit is washed away by the rains, while that in the blossom end would not in any case be consumed. The poison can not be absorbed into the fruit.

Banding the Trees.—It has been stated that the worms of the later broods often enter the fruit through the side, and that these are not so satisfactorily dealt with by the spraying. About the middle of June, or earlier, a burlap of old fertilizer sack or other heavy cloth should be placed about the trunk of the tree, not far below the lowest limb. Many of the worms, when they leave the fruits to spin their cocoons, will take refuge under these burlaps, and if they be searched under each week, and the worms and cocoons in the crevices of the bark beneath them be destroyed, a great good will be accomplished by lessening the number of moths which lay eggs for later broods. This, however, is a secondary measure, and not nearly so important as the spraying. It is often not essential, but it is advisable, where the pest is especially destructive.

THE PLUM CURCULIO. (Fig. 11.)

Conotrechellus nenuphar, Herbst.

General Description.—This insect is seldom seen on the apple, but injury by it is common. The injury consists in little hard, knotty spots on the surface of the fruit, usually appearing when the fruit is one-third grown or less.

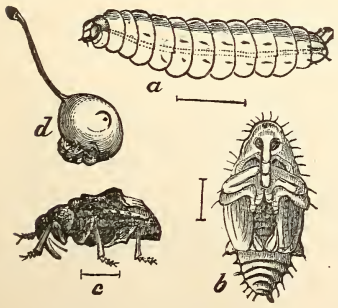

Fig. 11.—The Plum Curculio. *a*, grub; *b*, pupa; *c*, adult beetle; *d*, beetle at work on young plum, showing nature of injury. (From Lippincott Co.)

Life-history and Habits.—The Plum Curculio is the insect which causes the worm commonly found in the fruit of peaches and plums. It does not cause the worm in the apple (see Codling Moth, just discussed). The Curculio often punctures the fruit of the apple for the purpose of laying its eggs, though either the eggs do not hatch or the grubs die, for they do not mature in the apple. Thus, as the insect does not live on the apple, it is difficult to combat when it makes its desultory attacks on the fruit.

Remedies.—No specific recommenda-

tion can be given for combatting this insect on the apple, and it may also be said that its injuries to the apple are not often serious. It is a fact, however, that in orchards which are regularly sprayed with the Bordeaux mixture and Paris green, as described in the chapter on Spraying, the apples are not so badly attacked by this insect as in those in which this work is not done.

b. INSECTS ATTACKING THE PEAR.

1. Attacking the Trunk and Branches.

THE ROUND-HEADED APPLE BORER. (Fig. 2.)

Saperda candida, Fab.

This pest is discussed on page 6, as an enemy of the apple, as it is more destructive to that fruit than to the pear. The remedies there mentioned apply equally well when the insect attacks the pear.

THE FLAT-HEADED APPLE BORER. (Fig. 3.)

Chrysobothris femorata, Fab.

This insect is more serious to the apple than to the pear, and will be found fully discussed on page 8. The remedies there recommended are equally applicable to the pear.

THE SAN JOSÉ SCALE. (Fig. 7.)

Aspidiotus perniciosus, Comstock.

This insect has been discussed on page 12, under the head of "Insects Attacking the Apple."

It is worthy of special notice that Keiffer, Leconte and Garber pears are not (so far as yet known in this State), subject to serious injury from this scale, and trees of these varieties may stand unharmed in the midst of others which are killed by scale.

Remedies.—The remedial treatment for infested pear trees is the same as for apple.

THE SCURFY SCALE LOUSE. (Fig. 5.)

Chionaspis furfurus, Fitch.

This pest is discussed on page 10, under the head of "Insects Attacking the Apple." As the discussion there given applies equally well to the insect when it attacks the pear, it need not be repeated here.

Remedies.—The remedial treatment for pear is the same as that advised for apple.

2. Attacking the Leaves.

THE BLISTER-MITE.

Phytoptus pyri.

Description.—Very minute creatures (very closely related to insects, though not actually belonging to that group), scarcely at all visible even to the keenest eye, which form blackish blisters on the leaves of the pear. These blisters become conspicuous during June. The effect is to weaken the tree and reduce the crop.

*Life-history and Habits.**—The mites appear on the leaves as they are unfolding in the spring, and form bright red spots or blisters, having small openings on the under side of the leaf. The eggs are laid within the galls and the young escape through the opening and form new galls. As the season advances the galls change color, changing to green, and finally black. In the autumn, before the leaves fall, the mites leave the galls and enter the winter buds. Usually they are to be found beneath the two or three outer scales of the terminal buds, where they remain until the leaves unfold in the spring.

Remedies.—In experimenting on this pest, Professor Slingerland, of New York State, found that on trees which were sprayed with kerosene emulsion during the winter, this mite was scarcely noticeable, though other unsprayed trees near by were thickly infested. This indicates that the emulsion soaks into the crevices of the winter buds where the little mites are hibernating.

We would recommend that the emulsion be used at the strength of 20 per cent oil for this pest, always taking care to use no more than is needed to thoroughly dampen the buds and branches, and not allowing it to run down the trunk and in at the roots. Note also that this is to be applied in *winter,* even though the work of the pest is only apparent in summer.

We would not advise this treatment unless the mite has been numerous enough during the summer to do noticeable damage.

THE FALL WEB-WORM. (Fig. 9.)

Hyphantria cunea, Drury.

The discussion of this pest as given on page 16 will serve every purpose, both with regard to the general account and as to remedies.

CATERPILLARS (*Various species.*)

There are many other species of caterpillars which may attract the attention of the grower by devouring the leaves of the pear, but

*The account here given is adapted from M. V. Slingerland in *Insect Life, Vol. 5, p. 104.*

any of them may be easily overcome by spraying with Paris green and water, at the rate of one ounce of the green to ten gallons of water. Orchards which are regularly sprayed with the Bordeaux mixture of Paris green, as is advised, are not likely to be seriously troubled by the attacks of any kind of caterpillar on the foliage.

3. Attacking the Fruit.

THE PLUM CURCULIO. (Fig. 11.)

Conotrechellus nenuphar, Hbst.

The discussion of this insect on page 59 will serve every purpose so far as its attacks on the pear are concerned.

THE CODLING MOTH. (Fig. 10.)

Carpocapsa pomonella, Linn.

This insect is very destructive to both apples and pears, causing a large percentage of the "June drop," or "early drop," of these fruits. Infested fruits are apt to be unsightly in appearance, and will not keep so well as sound ones.

The insect is very fully discussed on page 19, and every grower should familiarize himself with the insect and the methods used to combat it.

---

c. INSECTS ATTACKING THE QUINCE.

The quince is not extensively grown in this State, and very few complaints have ever come to us regarding insect injury to it. We therefore omit any discussion of the insects affecting this fruit. Any which do serious damage will likely be found discussed under the head of Apple or Pear Insects.

Those most likely to do damage to the quince are the Round-headed Borer (page 6), the Flat-headed-Borer (page 8), and the Codling Moth (page 18).

II. FUNGUS ENEMIES.

By F. L. STEVENS, Biologist.

a. FUNGUS DISEASES OF THE APPLE.

THE APPLE SCAB.*

This disease, prevalent in all sections of the country, is too well known to all apple growers to need description. Its general characters are well shown in Fig. 12. It was recorded from North Carolina by Curtis as early as 1867.

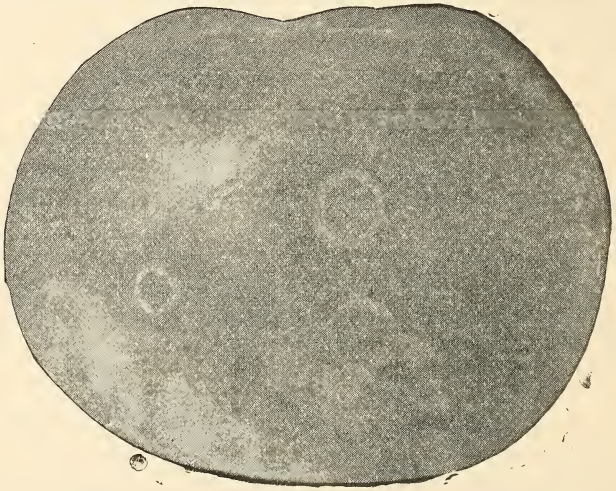

Fig. 12.—The Apple Scab.

The scab is caused by a parsitic fungus, which does great damage to the leaf as well as to the fruit of the apple. The spores, carried by the wind, fall upon the surface of the fruit or leaf, and there begin to grow, spreading from this central point of infection. Thus the diseased area is usually circular in outline. The fungus grows between the skin of the apple and the underlying tissue, and robs the growing parts of nourishment, causing the diseased regions to grow more slowly than other parts of the fruit, so that eventually the scab comes to rest in a slight depression. If several scabs attack the stem of the apple, they will so cut off the supply of nourishment from the young fruit as to cause premature falling. Similarly the presence of the fungus on the stem of the leaf may cause the death of the leaf. As the apple approaches maturity, the scab, if very abundant, will dwarf one side, giving the fruit a lop-sided appearance, which is quite characteristic. Owing to the premature falling, many apples affected most seriously with the scab escape observation.

*Fusicladium. Figures 1 and 2 are reproduced by permission of D. Appleton & Co.

Not only does this fungus damage the fruit directly, but it is also oftentimes present to a very serious extent on the leaves, where it causes a crinkling and an irregular ruffling accompanied by an olive coloration. Here it interferes greatly with the proper accumulation of nourishment, and results in a poorly nourished tree the following year. We can often trace the failure of the apple crop to poor nourishment the previous year, due to the presence of the scab fungus on the foliage.

Fig. 13.—Apple Mold Following Apple Scab.

While there is serious loss to the apple grower through the attack of the scab fungus upon the leaves and through the premature fall of apples directly traceable to the scab, the presence of the scab upon the mature fruit itself is probably the most serious injury. As was stated above, the diseased area is slightly depressed. Many scabs on the apple thus result in a marked injury to the size of the fruit; but more important than this is the unsightliness of the diseased apple, which, for this reason, falls considerably below perfect fruit in market value. An examination of apples in the bin in winter or spring will further show that in many cases the scabby regions rest in the center of the rotten portions. In fact, the scab has so destroyed the skin of the apple as to permit the entrance of those other fungi which cause the soft bin-rots (Fig. 13). Frequently whole barrels may be found in which every apple is scabby and nearly every scab is surrounded by a rotten area, varying in diameter from the size of a nickle to a fifty-cent piece, and eventually involving the whole fruit. In such apples the rot owes its presence to the scab, which prepared a way for its entrance into the otherwise healthy fruit.

Treatment.—The apple scab may be prevented by spraying with the Bordeaux mixture. It is advisable to spray from two to four times, according to the season. The first application should be made just before the buds open, followed by a second application after the blossoms fall. A third application should follow eight or ten days later. Winter spraying on the dormant wood, if the ground be soft, probably does more injury to the roots than will be compensated by the spraying.

The Bordeaux mixture should be made of five pounds of copper sulphate, five pounds of lime, and fifty gallons of water. It is well with the second spraying also to add one-fifth of a pound of Paris green to every fifty gallons of mixture, in order at the same time to prevent damage from the codling moth. Probably the Bordeaux mixture does not *kill* the scab when it is once upon the leaf or apple. Its chief value lies in *preventing the attack,* and in checking the spread. It should therefore be used early, placing all value upon prevention and expecting no actual cure.

One apple grower reports an increase of one thousand dollars in product from spraying, at an outlay of between $125 and $150. In the single State of Illinois, the apple scab is estimated to have caused $6,000,000 damage in one year, or 60 per cent of the total loss to the apple crop through all enemies. The value of spraying is brought out clearly in the following table, which is taken from results obtained in Missouri:

	Sprayed.	Unsprayed.
Clean	83.5	33.6
Scabby	16.5	66.4
Salable	92.9	69.0

THE FIRE BLIGHT.*

The fire blight, while one of the most serious of pear diseases, is much less injurious to the apple, although even here it is oftentimes of very serious importance, frequently causing dead spots on the trunks of the trees and blight to portions of the succulent branches and twigs.

Upon the twigs its presence may be recognized by the blackening of the bark and the wilting of the leaves as though stricken by fire. In the winter the diseased twigs are rendered very conspicuous by the retention of the withered leaves long after the healthy leaves have fallen. Very great damage also often occurs to the blossoms.

This disease, being pre-eminently a pear disease, will be discussed more fully in another bulletin treating of the pear. It may be said here that the disease is caused by a germ belonging to the great group of bacteria. These germs are extremely small, and multiply with very great rapidity. If one needs proof that this is a germ disease,

*Bacillus.

he may examine the diseased twigs under a microscope and see the germs for himself. They have the appearance shown in Fig. 14. No microscope is needed, however, to prove that the disease is contagious, for if one but make an incision in the bark of the healthy tree and transfer to this incision a small portion of the diseased bark from a blighted twig, he will find that the disease can be readily communicated from one twig to another. Under ordinary conditions, the disease is spread largely by insects which visit the blighted twigs for the sweetish liquid found on the bark. The insects then fly to another twig or blossom, bearing with them the germs.

Fig. 14.—The Germ of the Fire Blight Very Greatly Magnified.

Treatment.—The remedy consists in removing and burning all of the diseased twigs. In doing this, great care should be taken to cut low enough to insure the removal of all germs. The limit of the diseased portion can usually be told by the blackening of the bark, but it is usually best to cut a full foot below the diseased part, to avoid all possibility of leaving germs behind. It is also well to dip the knife in a solution of carbolic acid each time, before cutting into the new twigs, otherwise, perchance, germs may be left on the knife to be transferred with the next cutting to the new twig. Dipping the knife in carbolic acid precludes any such possibility.

The best time to trim for the fire blight is in the early spring, when the new wood is succulent and green. At that time the leaves and young shoots affected by the disease may be readily recognized. Careful and thorough trimming during the early spring and summer will prevent the greater part of the blight, and casual observation through the remainder of the year will hold the disease in check. In cases where large branches are removed and much surface exposed, the wound should be sealed, either with a grafting wax or with oil shellac, to which is added a little flowers of sulphur and a few drops of carbolic acid. This mixture may be applied with a paint brush.

It is a matter of common observation that trees in rich soil, which grow too rapidly, are more often affected by the fire blight. This is due to the fact that in such conditions the twig is more succulent, and hence less resistent to invasion by the germ. The fire blight also affects the pear, hawthorn and service berry, and these must all receive attention in order to eradicate the pest.

THE APPLE RUST.*

The apple rust may be readily recognized by its characteristic yel-

*Gymnosporangium.

lowish orange spot on the apple leaf. This spot, yellowish green at first, gradually becomes darker, approaching orange. Upon close examination, the upper surface is shown to contain very numerous black pimples, smaller than a pin hole, while upon the lower surface of the diseased spot there appear long curved horn-like projections. This spot is sometimes so abundant that its presence upon orchards at great distances may be recognized by the characteristic hue imparted to the foliage mass as a whole. It is needless to say that such rust of the leaf robs the tree of nourishment and renders perfect fruitage impossible.

This disease is due to a fungus growing in the leaf, and in this case we have a peculiar relation similar to that exhibited by the wheat rust, in that the fungus spends part of its life on one plant, the apple, and the remainder upon a totally different plant, namely, the red cedar. The fungus summers upon the apple tree (or its near relation, the quince, pear, hawthorn, or service berry), and toward the approach of winter spores from the apple trees are carried by the wind to some adjacent juniper or red cedar trees. Here the fungus grows and causes what every country boy is familiar with under the name of "cedar apple." The red cedar tree is the alternate host of the apple rust.

In the spring the cedar apple sends forth gelatinous horn-like projections, each bearing thousands of spores, which, when conveyed by the wind to the apple tree, may cause the apple rust. Evidence that this relation really exists is easily found if you examine an orchard having one or more red cedar trees upon its widward boundary. The rust is sure to infect a wedge-shaped area, with the apex of the wedge pointing toward a red cedar tree.

Treatment.—It is evident that the more red cedar trees in the neighborhood of the orchard, especially to windward, the more probability there is of damage from the rust. The rational treatment, therefore, is to remove all these trees in so far as is possible. In case of single red cedars too valuable to remove, carefully cut out and destroy all cedar apples in winter.

We know that in rare instances spores may be carried several miles, but we may render our orchards reasonably secure if we cut off all possibility of infection from the immediate neighborhood. In case the red cedars are too numerous, or if for other reasons it is impossible to cut them, spraying as recommended for the apple scab will probably lessen the evil.

THE BITTER OR RIPE ROT.*

This rot, as its name implies, imparts a bitter taste to the apple in the region of the decay. It is also found abundantly upon the ripe fruit, although by no means limited to such.

The decayed spots may occur either singular or in considerable

*Gloeosporium.

number on the apple, and if watched from day to day may be seen to enlarge slowly, spreading from the center outwards, thus maintaining a circular form (see Fig. 15). As the spot enlarges, small pim-

Fig. 15.—Apples Showing Different Stages of the Bitter Rot. Note the circular arrangement of the spore pustulas spreading from a center.

ples appear near the center, usually arranged in concentric lines (A in Fig. 16). As these pimples grow older, they break and assume a pinkish hue, which is quite charcteristic in this disease. The rot gradually advances until the whole apple becomes involved, it being changed into a shrunken, worthless mass (C in Fig. 15).

This disease is of fungus origin. Spores fall upon the surface of the apple, germinate, and, penetrating the skin, begin to develop in the underlying tissue. The small pimples seen on the surface of the decayed spots are clusters of spores which are ready to be washed off by the first rain, to infect new fruit. That the disease is contagious can readily be proved by inserting a few of these spores under the skin of the healthy apple, which will then rapidly develop decay.

This disease is particularly prevalent in the South, and has long

been of serious damage in our State, although we have no accurate estimate as to the exact injury done. In the State of Illinois, in 1900, it was estimated that $1,500,000 worth of fruit was destroyed upon the trees in four counties alone. Professor Burrill says, "There is no other disease that is so enormously destructive to the apple fruit as the one commonly called the bitter rot."

The spores of the bitter rot are sticky, and in no way adapted to wind conveyance. It has therefore been a serious question as to how they are spread to the apples as they hang upon the tree during

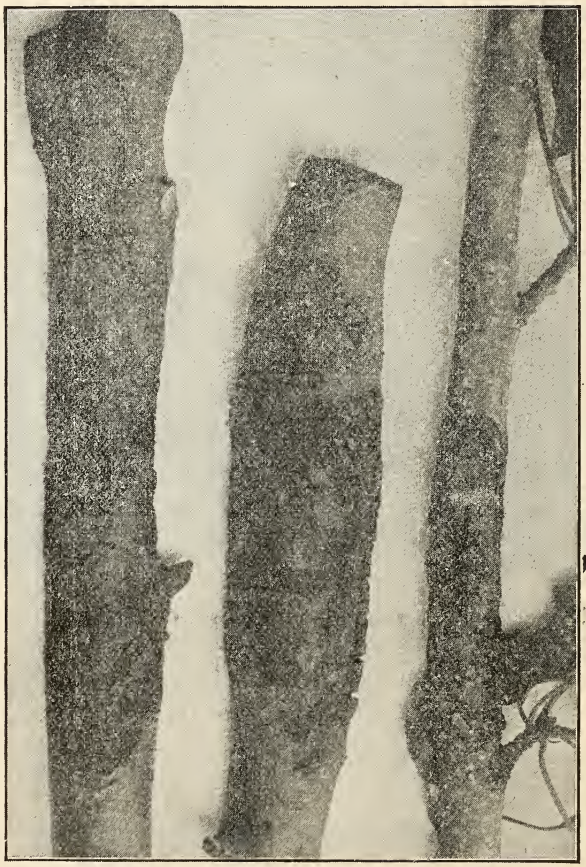

Fig. 16.—Types of bitter rot canker.

summer. A very recent observation by Capt. R. S. Simpson in Illinois, followed by some careful field work by Prof. T. J. Burrill, seems to prove that the same fungus that causes the bitter rot also causes what may be known as the *bitter rot canker* on the apple tree twigs.

The bitter rot canker starts often from a bruise, and consists of a sunken bark wound from two to four inches long, with a ragged border, as illustrated in Fig. 16. It is usually found on limbs varying from half an inch to an inch in diameter, though it sometimes grows on smaller twigs. The attack seems to be limited to the bark, as the wood is not injured. Careful inoculations have proven that the spores taken from the bitter rot of the apple will cause the canker of the twig, and that the spores taken from the canker will cause the bitter rot on the fruit. Moreover, it is noticeable in orchards that early in the

Fig. 17.—Diseased Apples and Cankered Limbs. Note proximity of rot to canker.

season apples suffering from the bitter rot are usually affected first on their upper surface, and that above such affected apples we may find the apple canker. Indeed, there seems to be almost complete proof that the infection of each season starts with the canker, the spores being washed down by rain to the apples below. It thus happens that the diseased apples of a given portion of a tree are found to be arranged in the form of a cone, and at the apex of this cone is a bitter rot canker, the initial source of infection. Fig. 17 shows such a canker with the apples immediately below infected upon their upper surface by spores splashed from the canker above by drops of rain.

Treatment.—It follows from the relations existing between the apple canker and the bitter rot that the same treatment should be employed for each, and that the prevention of the canker means also the prevention of the rot. The orchard should be carefully and systematically inspected, and all cankers removed, thus doing away with the source of infection. Spraying with the Bordeaux mixture will kill many spores, and thus prevent much infection. It is possible that both of these means should be employed, and in addition to this, great care should be exercised, both at time of pruning and picking,

in order to avoid bruising the bark of the twigs, and thus to a great extent prevent the development of the canker on the tree. It is probably advisable also to apply a strong solution of pure copper sulphate, 1 pound to 18 gallons, to the twigs and branches in winter at the time of pruning.

OTHER CANKERS.

There are several other types of bark wound or disease which are grouped under the general term of "canker." These all have a general resemblance to the bitter rot canker, yet have slight specific differences, the cankers being due to different species of fungi. The injury is at first local, but frequently results later in the death of the affected limb.

Treatment.—As these are caused by a fungus which enters through a bruise, three preventative measures are suggested:

1. Destroy cankered limbs to reduce the sources of infection.
2. Avoid bruises.
3. Spray with Bordeaux to prevent germination of spores.

THE BLACK ROT.*

This disease of the apple looks very much like the bitter rot, so much like it, indeed, that it would be impossible to distinguish one from the other in an illustration. However, the black rot possesses a prevailing blackish hue, while the bitter rot has no black color, but is reddish or pinkish. The spore pimples of the black rot are black, while in the bitter rot they are pink. In other details the two rots closely resemble each other. The black rot is very abundant on green apples, which very frequently fall owing to its attack. Sometimes also it is bad on ripe apples and on fruit in market. The fungus which causes this disease, like the bitter rot, also causes a canker on the bark of twigs.

Treatment.—Methods of eradication should look to an elimination of the canker, and spread of the disease should be checked by the use of the Bordeaux mixture.

SOFT ROTS.

There are numerous kinds of soft rots which affect ripe apples in the bin. These are all due to the attack of fungi, which effect an entrance to the apple through bruises or breaks in the skin. Once inside the skin, the fungi grow rapidly through the fruit, converting it to an impalatable, disagreeable mass. The fungus thus proceeds to spore formation and apples in the latter conditions of decay are seen to be covered with veritable forests of fungus hyphæ laden with

*Sphæropsis.

spores. If healthy apples are lying in contact with such an affected apple, they also will succumb.

Treatment.—Very little can be said regarding the protection of fruit from these soft rots, other than to emphasize the need of care to preserve the skin of the apple in sound condition, since bruises or cuts render the entrance of the fungus possible. Cold storage retards the growth of the fungi.

THE POWDERY MILDEW.*

The powdery mildew is a disease of apples which is of most injury to nursery stock, often becoming so serious as to prohibit successful budding. The use of the ammoniacal solution of copper carbonate as the leaves unfold, and continued at intervals of two weeks until budding time, will effectively prevent this disease.

*Podosphæra.

b. FUNGUS DISEASES OF THE PEAR.

THE FIRE BLIGHT OF THE PEAR.*

The name fire blight is well chosen, since the affected tree with its shriveled branches and shrunken, blackened twigs gives the impression of injury by fire. In many cases even whole orchards have succumbed to its attack. One pear grower near Washington, D. C., estimates his damage from this one disease in one year at $10,000. The disease is widely known throughout this State.

During winter the disease may best be recognized from the fact that the leaves of the diseased twigs do not fall as do those of the healthy twigs. In the early spring, when the disease is most aggressive, the blighted twigs may be known at a glance by their shrivelled, darkened leaves, while on closer examintion the black bark attests clearly to the presence of the fire blight.

This disease has been know for at least one hundred years, and affects the apple, quince and hawthorn, as well as the pear. It is known sometimes as a twig blight, and at other times as a flower blight. So much discussion was caused by it in earlier years, and that to so little effect, that the Western New York Horticultural Society resolved to allow no further hearing of the subject unless entirely new facts were forthcoming.

Many theories as to the nature or cause of the fire blight were advanced, among which might be mentioned those depending upon electrical or atmosphere influences, freezing of the bark, too long culture of particular varieties, freezing of the roots, too high culture, insects, absence of needed food, and fungi. One of the most prominent among these, put forward by the well known apple expert, Mr. Downing, was known as the "frozen sap theory," according to which the disease was due to the freezing and thawing of the sap, resulting in a loss of vitality and a development of poisons in the tissues. It is unnecessary to discuss any of those theories further than to say that none of them succeeded in explaining all the facts.

In 1878, Prof. Burrill discovered in the diseased twig very many minute living germs, or bacteria. He transferred a portion of wood and bark from diseased twigs bearing these germs into healthy twigs and found that the blight was also transferred. By dipping a needle into a solution containing the germs and then pricking the needle into the bark of a healthy twig, he also caused blight. This led him to believe that the germs cause the blight. Objections to this view were raised by some on the ground that substances other than the germs were transferred. To meet these objections, Pro-

* Bacillus.

fessor Arthur later cultivated the germs for several generations in nourishing substance and then inoculated the germs into healthy trees, producing the disease. To prove that it was the germs and not the liquid that caused the blight, he filtered his culture and then inoculated trees with the clear solution free from bacteria. No infection followed. The proposition now seems absolutely proven that it is the minute germs that cause the blight.

A true idea as to the nature of these germs may be had from Fig. 14. We must realize that the germs are approximately only one twenty-five thousandth of an inch long. They grow in the juicy, succulent twigs, particularly in the cambium, that juicy part of the stem lying between the bark and the wood. These bacteria have no independent means of passing from tree to tree, and for transportation are almost entirely dependent upon insect visitors which frequent the diseased twigs in order to secure the sweetish solution which exudes from the surface in drops. These drops are teeming with bacteria, and the insect visitors carry on their feet thousands and even millions of them to infect the next tree visited. The disease is often conveyed by insects to the blossom, which being an especially succulent and tender portion, furnishes ready access as well as suitable conditions of the development of the germs.

It thus happens that the disease spreads rapidly, doing most damage in spring, owing both to the prevalence then of the succulent stems and branches and to the more ready insect transportation. It has been demonstrated that the germs can not gain access through healthy mature bark, but will readily penetrate into any wounded place, or into the succulent bark of rapidly growing twigs.

It is a matter of common observation among pear growers that trees in too rich soil are almost sure to be affected. This is entirely explainable from the fact that such soil produces a greater amount of succulent, rapidly growing shoots. So too any cause, such as too much pruning, too high fertilization or cultivation, or anything tending to promote too rapid growth, favors the blight. Such conditions are to be avoided, thus lessening the liability to infection; yet this advice must not be followed too far, or the tree will suffer from maladies other than the blight.

The proper way to eradicate the blight is to remove the source of infection. To do this, we must remove from the vicinity all infected wood; we must cut out and burn all diseased twigs, leaves or branches, either on the pear, apple, quince, hawthorn, or related trees, which might otherwise furnish bacteria for the bees to carry into our orchards. If this be done, and done thoroughly, the disease can be entirely controlled. I heard a prominent fruit grower say this summer that no man with a sharp knife need fear the blight.

The proper time to cut is whenever affected branches are seen. In

the autumn, after the falling of the foliage it is especially easy to recognize diseased branches, owing to their conspicuous retention of leaves. Also in the spring, when the blight begins to take hold, especial care should be taken and frequent inspection given to the orchard. At this time diseased twigs are also easily recognizable. It is well to cut at least a foot below the affected region, as all germs must be removed to secure safety. The greater part of the blight will be removed without difficulty by one thorough fall and spring pruning. After these, occasional inspection and needed trimming will hold the enemy in check.

Whenever limbs are cut off or bruises made, cover the wound with paint, grafting wax or some other compound,* to prevent the access of rot-causing fungi and blight bacteria.

If the pruning knife at any time cuts into the diseased wood, it will become smeared with germs. These should be killed by dropping the knife into carbolic acid before cutting again in to healthy wood.

THE ANTHRACNOSE.†

This disease was first seen in 1892 by the writer on a pear tree in New Jersey, where it destroyed nearly every fruit on the tree. It is very serious, but fortunately not of frequent occurrence, and has not yet been recorded in this State. In nature, cause and appearance, it closely resembles the ripe or bitter rot of the apple, and the treatment may be the same as for that disease.

THE PEAR RUST.‡

The rust of the pear is very similar in nature to the rust on the apple which has been discussed on other pages in this bulletin. It consists of two stages, a summer stage and a winter stage. The summer stage produces the rust on the leaves of the pear, while the winter stage forms the familiar cedar apple.

The remedy, as in the case of the apple, consists in removing all cedar trees from the neighborhood of the pear orchard, thus eliminating the source of infection. When this is impossible, the trees should be sprayed with the Bordeaux mixture immediately after the early rains which cause the gelatinous horns on the cedar apple, and thus furnish the supply of spores for the spring infection.

This disease of pears is particularly abundant upon several varieties of the Japanese strain.

THE PEAR CANKER.

There is a canker on the pear closely related to the cankers de-

* Oil shellac, to which is added a little flowers of sulphur and a few drops of carbolic acid is recommended by the Connecticut Experiment Station.

† Colletotrichum.

‡ Gymnosporangium.

scribe for the apple. That they are of fungus origin has been proved by many inoculations.

It is probable that spraying the bark with Bordeaux mixture would partially or wholly eradicate this enemy, although no experiments seem to have been made on this subject.

THE PEAR SCAB.*

The pear scab is familiar to all who raise the pear. It consists of a surface blotch or scab, often accompanied by a peculiar cracking (see Fig. 18). This, however, is a secondary effect which is not

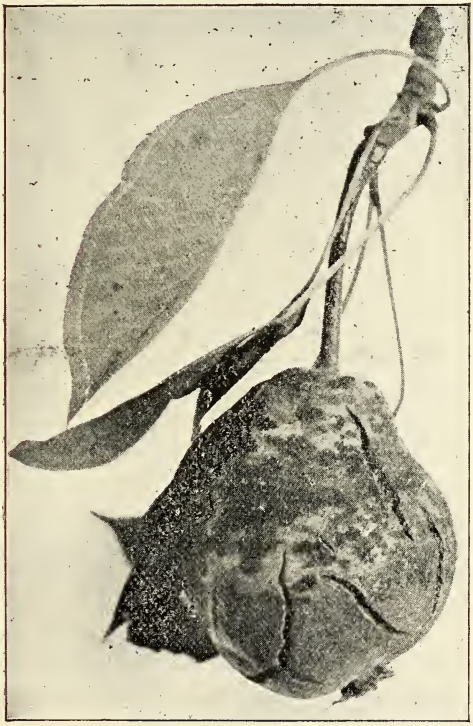

Fig. 18.—The Pear Scab.

necessarily present; a cracking may even accompany other diseases.

The pear scab is caused by a fungus which is very similar to that which causes the scab on the apple. Indeed, the characters of the two are so closely alike that it is still a debated question whether the two diseases are not identical. Fig. 19 shows the microscopic structure of the scab. The black stalks sticking above the surface

*Fusicladium.

are the branches of the fungus which are to bear the spores, and the three roundish oval bodies are spores which have just separated from their place of origin. The threads or mycelium of the fungus lie

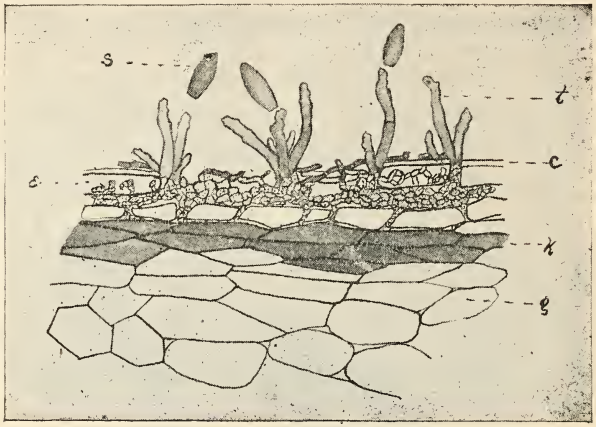

Fig. 19.—The Hyphæ of the Pear Scab Fungus Bearing Spores.

below the skin c, and there suck up nourishment, and cause discoloration, as is the case with the apple. The fungus passes the winter on the bark, as well as upon the diseased fruit and leaves.

Treatment.—This disease has proved amenable to treatment. Results from the Vermont Agricultural Experiment Station show a benefit in both quantity and quality from spraying with the Bordeaux mixture, the market value of the fruit being increased from twenty-five to fifty per cent, for example, in case of the Flemish Beauty Pear. In some cases, the value of the sprayed crop being placed at one hundred, the crop which was not sprayed brought a value of only forty-seven.

The treatment for prevention consists in spraying to kill the spores and to prevent the development of the fungus. The first spraying should be made before the leaves open, and should consist of the copper sulphate one pound and water eighteen gallons. The Bordeaux mixture should then be used three times: first, just before the blooms open; second, after the flowers fall; third, about two weeks later. The Bordeaux mixture should be of the usual strength, five pounds of copper sulphate, five pounds of lime, and fifty gallons of water.

THE LEAF SPOT.*

The leaf spot, while never completely destructive to foliage or crop, does interfere with the general productiveness and health of the

*Septoria.

tree by diminishing its green surface. The leaf spot may be distinguished from the scab and the blight by the fact that the diseased area is rather sharply defined and characteristically angular in out-

Fig. 20.—The Pear Leaf Spot.

line. The center of the spot, usually of an ashen color, is surrounded by a brown zone, and this in turn by a purplish one. The ashen center bears several exceedingly minute dark-colored pimples. One of these in section is shown in Fig. 21. The pimple is really a hollow structure containing numerous worm-shaped spores. Each of these spores finding favorable lodgment upon another leaf, is capable of reproducing the disease. The treatment recommended for the pear scab is effective in preventing this disease.

THE LEAF BLIGHT.*

The leaf blight of the pear is almost as widely distributed as is the pear itself. The spot caused by the leaf blight does not exhibit

*Entomosporium.

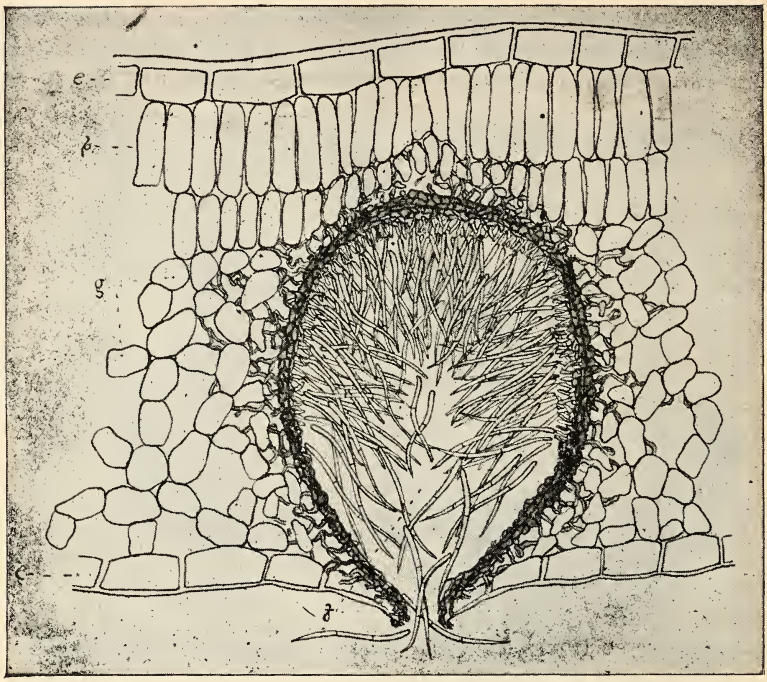

Fig. 21.—Section of a Pear Leaf Showing the Leaf Spot Fungus and Its Spores.

the striking zonal arrangement described for the leaf spot, and the whole leaf more often takes on a diseased appearance, eventually turning yellow or brown and falling. This disease is also prevalent upon the fruit where it causes a red spot. This soon becomes darker, and may later be accompanied by a cracking similar to that of the

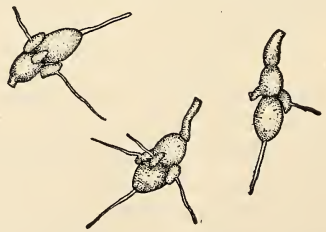

Fig. 22.—Spores of the Leaf Blight Fungus.

pear scab. The spores are produced in the center of the diseased spots, and are decidedly different from the spores of the fungi of the other pear diseases, as may be seen in Fig. 22.

The treatment already recommended for the pear scab will suffice for the pear leaf blight.

c. FUNGUS DISEASES OF THE QUINCE.

THE QUINCE RUST.*

The quince rust is caused by a fungus which agrees with the apple rust fungus in general characters. That is, the fungus grows upon the quince fruit in the summer and produces there myriads of spores, which on the approach of fall are carried by the winds to adjacent cedar trees, and there produce the large galls commonly known as cedar apples. These galls enlarge during the fall and winter, and in spring give origin to long gelatinous horns, which consist in reality of masses of spores imbedded in a matrix of jelly. These spores upon drying are conveyed to the quince tree by the winds, and there produce again the quince rust. The cedar is a necessary resting place for this fungus during the winter, and if the cedar trees in the neighborhood be destroyed the quince rust must of necessity disappear. The remedy, therefore, in this case is if possible to remove the cedars from the neighborhood of your quince trees. This will almost entirely prevent the rust, although in rare instances spores may be carried from considerable distances. Infection has been known from as great a distance as eight miles. You may feel reasonably secure, however, if you remove all of the cedar trees in the near vicinity of your orchard. In case the cedar is too abundant in your region to permit of its complete removal, you must resort to spraying the leaves and fruit of your quince trees with the Bordeaux mixture at the time when the rust spores are expected to arrive. That is, at the time when the gelatinous horns are present on the cedar apple.

THE FIRE BLIGHT.†

This disease has been thoroughly discussed in connection with the pear and apple. It is only necessary here to indicate that it is the most serious disease of the quince known. The treatment is the same as that recommended for this disease on other pomaceous fruits, namely, to cut out and burn the diseased portions, cutting each time fully a foot below the disease in order to insure complete removal of the infected wood.

LEAF BLIGHT AND FRUIT SPOT.‡

These diseases affect both the fruit and the foliage, causing upon the foliage a spotting and a premature falling, so that the vitality and vigor of the tree is much impaired. Upon the fruit it causes black blotches, first seen as small brown spots, which soon increase in size and turn darker in color. While this spot does not materially injure

*Gymnosporangium. †Bacillus. ‡Entomosporium.

the fruit for use, it does retard its full development and by disfiguring the beauty of the fruit decreases its selling price. The disease is of fungus origin, and it spreads from tree to tree by spores borne by the wind. Consequently the means for prevention will consist in protecting parts which have not yet been attacked by a thorough application of the Bordeaux mixture. Repeated trials have shown that this treatment is thoroughly effective, increasing the value of the quince crop very materially; the increase being both in the size and the quality of the fruit. In an experiment in New York in a large commercial orchard the fruits from the sprayed rows were nearly twice as large as from the untreated rows alongside. The first application should be made soon after the blossoms fall, and should be followed at intervals of two or three weeks with two more treatments.

THE BLACK ROT OF THE QUINCE.*

This rot is due to the same fungus which causes the black rot of the apple, and the treatments recommended for the apple will undoubtedly prove efficient for the quince disease. It has not yet been proved that this fungus causes cankers on the quince trees such as have been described for the apple. The grower should, however, watch carefully for the presence of canker, as the relation between the canker and the rot in the apple indicate that the canker may possibly be found on the quince also.

THE RIPE ROT OF THE QUINCE.†

This disease is caused by fungus identical with that causing the ripe rot of the apple. The treatments already recommended for other diseases will also prove efficient for this rot.

d. FUNGUS DISEASES OF THE PERSIMMON, POMEGRANATE AND FIG.

While several diseases are known to affect these fruits no particular attention has yet been given to them, owing to the slight commercial importance of the fruits in question in this State. Several of the diseases of the pomegranate, persimmon and fig are undoubtedly identical with similar diseases of the fruits mentioned in previous pages of this bulletin, and the treatments recommended here will probably prove useful with these fruits. Any persons suffering from injury by disease to the pomegranate, persimmon or fig, are requested to send to the Experiment Station the diseased leaves, twigs or fruits, that a study of the same may be undertaken.

*Sphæropsis. †Gloeosporium.

Bulletin No. 184 April, 1903

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

THE CULTURE AND MARKETING OF ORCHARD AND GARDEN FRUITS

INCLUDING

THE PEAR, THE CHERRY,
THE PEACH, THE QUINCE,
THE PLUM, THE FIG,
THE POMEGRANATE.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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The Director's office is in the Agricultural Building. Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

ACKNOWLEDGMENT

The cuts of fruit in this and the previous Bulletin on The Apple, are from photographs taken by Mr. T. K. Bruner, of the Department of Agriculture. They represent actual scenes and conditions in the State, and the Station is indebted to Mr. Bruner for placing them at its disposal.

B. W. Kilgore,
Director.

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CARMAN PEACH.

THE CULTURE OF ORCHARD AND GARDEN FRUITS.

By W. F. MASSEY, Horticulturist.

I. ROOTS, STEMS, BUDS, LEAVES AND FLOWERS AND THEIR FUNCTIONS; CLASSIFICATION OF PLANTS.

1. Trees and Plants as Living Things.

A plant or tree is the result of vital forces acting in accordance with fixed laws. None of the operations of life in plants, any more than in animals, are the result of chance. Nature, operating under these laws, never makes any mistake. We may not be able to discover under the microscope any particular difference between the embryo in the apple, pear or quince seed, but the apple obeys the laws of its ancestry, and never, under any circumstances, developes into a quince or a pear. In like manner the embryo in the wheat or oat seed always develops into a wheat or oat plant, and never, as some imagine, makes a mistake and developes into a different plant. A careful study of the laws of nature will prevent any intelligent man from falling into such delusions. The study of these laws which the Creator has ordained for all the operations of life in plants is important to the proper understanding of the methods of culture and training to which trees in our orchards are subjected. We are thus enabled to do the work in a rational manner, and will always be ready to give a reason for every process we use in the propogation, planting and pruning of trees.

2. Two Classes of Plants.

Botanists find that all plants can be divided into two great classes, so far as concerns those which makes true flowers and seeds—those which, in sprouting from the seed, form but one seed leaf, and those which form two or more seed leaves. These differences in the embryo and the seed are connected with other differences all through the life of the plant. Those which make but one seed leaf, make all their subsequent growth in a different way, and produce flowers of a different structure from those which make two or more seed leaves. For convenience, though perhaps not with the strictest accuracy, we call those which produce but one seed leaf in germination "inside growers or Endogens," and those which make two or more seed leaves

"outside growers or Exogens." Many of our herbs, such as the grasses and cereals belong to the class of Endogens while all the trees of this latitude, except the Palmetto, belong to the second class. Indian corn is a familiar example of an endogenous plant, while any of our fruit trees will be a good example of an exogen. Endogens, in germination, seldom form a tap root, while the exogens, as a rule, do so.

3. How Trees Grow.

All vegetable growth is made by the formation and multiplication in various forms of minute boxes or cells, in which the living principle, which carries on all the work of the plant, exists. These cells are added by this living matter very much like the bricks are added

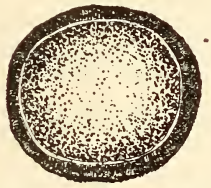


FIG. 1. Section of stem of an Endogen, *e. g.*, cornstalk.

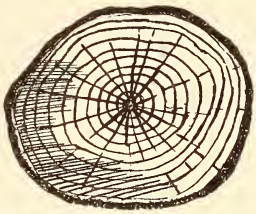


FIG 2. Section of stem of an Exogen, *e. g.*, fruit tree.

to a wall, but the brick-maker and the mason live inside the cell walls which they have constructed from substances carried in their own substance. In our fruit trees these cells are formed at the growing tips in a group of cells that have still the power to divide, and down all between the bark and wood, making wood cells and bark cells simultaneously. So long as these cells are young and their walls unhardened there is an intimate connection between the living matter in one cell and its neighbors of like age throughout the growing tissues, so that food is conveyed from one to another in any direction where increase of cells is going on from the extreme tips of the most delicate rootlet to the point of the tallest twig on the top. As the cell walls are thickened and become woody from additions made by the living matter within, this intimate connection ceases. Some of the young cells are early in their formation drawn out into long tube-like shapes, through the walls of which in the younger sap wood the ascent of the sap water from the soil to the leaves takes place. These vessels are arranged in bundles and when they reach the leaves can easily be seen in the frame work of the leaf, which we call the veins. In the leaves takes place every combination of material out of which new cells are formed, constituting what we call growth. The transfer of this elaborated material takes place through the youngest bark cells, while the crude sap water comes up through the younger wood

cells. The leaves, then, are the laboratory of the plant, and all growth, whether of roots or top, depends on the matter elaborated in the leaves, and on the kind of leaf depends the kind of wood formed in roots and top. Apple leaves always make material for apple wood and pears make pear wood and nothing else for root and top alike.

In the first year's growth we find that there is in the center a soft part called the pith, through which the sap water ascends during the first season. After the first year this office is taken by the young sap wood and the pith is no longer of use. It grows less and less in size from the pressure of the wood around it as the limb grows older, and finally almost disappears. As the wood cells are completed and all of the living matter in them is exhausted, the wood becomes heart wood, or finished wood, and no longer contains any life, nor takes any part in the growth of the trees, except to act as a support while the life circles around it year after year, adding new cells in ever-widening circles, and gaining in thickness as more and more wood is finished. When a piece of sap wood is cut, the living matter dies, and on this death grow low forms of plant life we call fungi, which more or less rapidly cause it to decay. When heart wood is cut, there is no life there for fungi to feed on. Hence it decays more slowly. The jelly-like layer between bark and wood is seen under the microscope to be formed of cells as regular as a honeycomb, and for convenience we call this series of layers of forming cells the cambium layer. Upon the character of this layer depends all the success of our operations in grafting or budding.

4. The Motion of the Sap.

There is an old notion that the sap rises from the ground in the spring in our trees and descends in the fall, making a sort of circulation. But there is nothing in plant life that is at all comparable to the circulation of blood in animals. We understand the processes better now. The so-called sap, which rushes up through the young sap wood in the spring is nothing but water, in which is dissolved the mineral elements and nitrogen compounds which plants get from the soil. A large part of this water is transpired or evaporated from the leaves, and with the concentrated residue, and the carbon which the leaves get from the air under the influence of sunlight, the plant forms all the living matter and material for building its cell walls. These materials are then transported through the cambium of the young bark to every part of the tree where growth is being made, whether it is root or top, and there is never anything like what was formerly called the descent of the sap, though growth necessarily descends from the leaves to the roots.

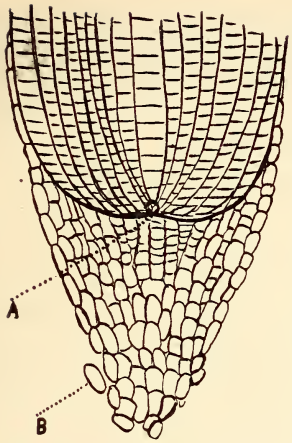


FIG. 3. Magnified section of a root cap of a grass. A—Point where new growth takes place. B—Older cells of cap wearing away.

It was formerly thought that the tips of the rootlets were spongy and absorbed water as a sponge does, and the older botanists talked of the "Spongioles" on the tips of the roots. We now know that there are no spongioles, but that the extreme tip of each rootlet is of older material than that just behind it; that the end of the rootlet is analogous to the bark, and that the young forming cells are just behind it, making growth both to the end of the root and to the under side of this root cap, so that the growing point is always protected in pushing through the soil, and the cap is continually being renewed from behind as the outer cells wear away in the soil. The wisdom of this arrangement is obvious, for if the youngest formed cells were at the tip itself, the root could not press its way in the soil without destroying them. The tip, then, being of older material, can not absorb the water from the soil, and this is provided for by another arrangement. Just back of the tip of the root it will be found in most plants that there is a coating of velvety hairs, easily seen under the microscope, and often by the naked eye. These hairs are formed on the youngest part of the root as it presses through the soil, and dry up and disappear as the rootlet becomes older. It is through these hairs that the root absorbs the water from the soil, laden with plant food, and as new ones are being formed as the root presses forward, the plant is always seeking food in fresh soil. The older roots merely furnish the conduit through which the water absorbed by the root hairs passes to the tree, and through which the material for growth is sent from the leaves to the roots. Most of the feeding rootlets, with their absorbing root hairs, will therefore be found out where the rain drips from the limbs, for the roots are generally as far out as the branches above, or even farther. While all of our fruit trees at first make a tap root, this is, even in the seedlings, soon followed by a multitude of lateral roots, which spread through the surface soil and greatly increase its feeding area. In nursery-grown trees, where the cion is grafted on a tap root, the tip of the tap root is cut off, and no tap root forms again as a rule.

It is easy to see, then, that the application of a pile of manure right around the stem of a large tree can do little good, when the feeding roots are away out where the limbs drip. The spreading surface roots are the most important ones to the tree, and any treatment that injures them is a check to the tree. In some trees, like the

chestnut and others, the tap root persists, and they are proverbially hard to transplant after a few years growth in one place. Such trees should always be lifted at the end of the first year, and their tap root shortened so as to encourage the formation of lateral roots, making them easier to move when wanted for final planting. Hence, most of our evergreen trees need to be often transplanted in the nursery while young.

5. The Difference Between Roots and Stems.

To the casual observer who has not studied plants, everything under ground is a root. Therefore we hear people talking about the roots of the reed and Bermuda grass, when they really refer to the creeping stems that are often underground. Stems grow by the regular addition of joints and the spaces between the joints. Botanists call these nodes and internodes, or the space between the nodes. True roots grow only by increase in length under the root cap, and their branching is at random. They make no regular succession of nodes or joints. Therefore when we find a form with regular joints, like the so-called roots of the reed and Johnson grass, that form is a stem in its nature, and not a root. Roots branch in regular form from the buds at the nodes. When there are two buds at a joint, there will be opposite branches formed, but where only one bud appears there will be branching only from that bud. Branches seem to be formed on roots just as there is food to seek at any point. Nevertheless, there are found buds on some true roots, which are called adventitious buds, and from these bud shoots will be formed. These buds are common on plants like the blackberry and red raspberry, and are made use of in propagating plants from cuttings of the roots. These adventitious buds on the roots are the cause of the suckers that bother us in some of our fruit trees, and keep up a renewal of the stock on which the tree is grafted. Stems, then, may be under or over ground. Roots, too, sometimes emerge from plants above ground, and are called ærial roots. These are common on our Scuppernong grapes, and in some of the trees of the tropics, like the great fig or banyan tree, they reach the ground, send out feeding tips, and the older part is transformed into a stem like the original, and the tree spreads in this way over a great area.

6. Buds.

A bud is the beginning of a branch or a flower shoot, and sometimes both. A wood bud starts a new branch when it appears at a node. When it terminates a shoot, making the terminal bud of the season's growth, it simply elongates that stem when it starts to grow again. Most of our fruit trees have buds covered with scales as a winter pro-

tection. When the bud swells in the spring, these scales fall away, leaving creases in the bark which remain for some time and mark the beginning point of the season's growth.

7. Leaves and Their Functions.

The leaves of a tree are the most important organs of growth. More than nine-tenths of the organic matter in the tree comes from the air, by means of the assimilation of the carbon, from the deoxidation of carbon dioxide or carbonic acid gas by the green matter in the leaves under the influence of sunlight. This is true of every plant that grows, and shows the great importance of healthy foliage, since no plant or tree can make growth or ripen fruit without healthy leaves. The leaves have in their surface, mainly on the under side, millions of tiny pores, opening and shutting like miniature lips. These are open when the sun shines and closed at other times. They open between the loosely arranged cells in the interior of the leaf. These cells contain as part of their living matter certain irregular shaped grains of a green color. The air has always in it a minute portion of carbon dioxide. When the pores in the leaf are open, this carbon dioxide gains entrance. Then the green matter of the leaf has the wonderful power to decompose it, throwing off the oxygen and taking the carbon for the living matter to use in the building of cell walls. In this way plants purify the air, by taking the carbon dioxide, which is poisonous to animal life, and restoring the oxygen, which is needed in the air. With this carbon and the water taken up by the roots in which the mineral matters and nitrogen compounds are dissolved, the plant manufactures in the leaf all the various substances which are used in its growth. The sap water from the soil reaches the leaves through the bundles of tubular vessels forming the veins of the leaf, which are in direct connection with the roots through the stem, and there meets the carbon from the air.

Leaves are arranged on stems in various ways. When there is but one leaf at a node. the successive leaves above form a spiral, making one or more turns around the stem before another leaf comes directly above the first one. We call this the alternate arrangement, and it is the common one in our fruit trees. When two leaves are at a node they are on opposite sides, and the arrangement is called opposite. When more than two grow at a node, they are called a whorl. The branching of a tree is governed by the leaf arrangement, for the buds that make new branches are formed in the axils of the leaves, or the angle which the leaf makes with the stem. Hence, if the leaf arrangement is alternate, the branching will be alternate, and if they are opposite, the branches will also be opposite.

Leaves not only take food from the air, but they pass off or tran-

spire into the air the surplus moisture in the shape of invisible vapor, thus condensing the watery sap brought up from the roots. This evaporation of water is shown by the rapid wilting of the leaves when the shoot is severed from its connection with stem and roots.

8. The Flowers and Fertilization.

Botanists regard the flower on a plant as leaves transformed in various ways for the purpose of producing fruit and seeds for the reproduction of the plant. A complete flower consists first of a row of transformed leaves at the end of the flower stalk, commonly green in color, called the *calyx* of the flower, and the separate leaves of the calyx are called *sepals*. Inside this circle of the calyx is another circle of flower leaves still more transformed in appearance and variously colored. These form the *corolla* of the flower, and the separate leaves are called *petals*. Inside of these comes another circle, usually more numerous or in several circles, called *stamens*, each of which consists of a slender filament at the end of which grows an *anther*. In this anther there is produced the pollen of the flower or the male element, generally yellow and dustlike to the naked eye, but which, under the microscope, is seen to be variously shaped cells filled with living matter. In the center of the flower is another circle or a single form called the *pistil*. This consists of a tube-like stem called the *style*, on the tip of which there is a variously formed surface without skin or cuticle and for a time moist, called the *stigma*. The style grows out from the ovary or seed vessel in which are certain bodies known as *ovules*. The pistil is the female organ of the plant. When the pollen falls on the moist surface of the stigma, it swells and grows into a long tube, passes through the tissues of the style and reaches the ovules. In the ovules there is then a new growth set up, which finally takes on the form of an embryo and the ovule then becomes a seed. This process is called fertilization or impregnation. When this fertilization takes place from pollen of the same plant, the seed will probably reproduce that plant, but when pollen from another plant of the same species is brought to the flower by insects or otherwise, the result is a cross of the two. Hence we find that our fruit trees seldom reproduce the same variety as that from which the seed came, because they are more apt to be fertilized by other pollen than their own, as the pistil is usually ready for pollen before the pollen in the same blossom is ripe, and a roving bee supplies it from elsewhere. Therefore, to reproduce the same variety, we have to resort to cuttings of the variety grafted or budded on a similar stock.

9. The Fruit.

Botanically, the fruit of any plant is, in the strictest sense, the ripened ovary of the pistil, with its seeds. But in many plants other parts persist and are attached to the ovary in ripening, and all taken together form what we call the fruit of our orchard trees. In the apple, pear and quince the ovary is completely enveloped and embedded in the calyx, which continues to grow as part of the fruit, and what we commonly call the fruit of these trees is really the calyx, and the core or true fruit is contained within this. In the strawberry the part we call the fruit is really the swollen end of the receptacle on which the flower grew, and the true fruits, the separate carpels of the ovary, are borne in the little depressions on the surface and pass simply as seeds. In the peach and other stone fruits, the walls of the ovary itself thicken up and give us a pulpy, edible part around the hard inner shell which surrounds the seed. The sugars and acids of fruits are compounds of carbon, hydrogen and oxygen, formed by the leaves from the carbon taken from the air and associated with hydrogen and oxygen. It is evident, then, that the quality of the edible fruit depends on the health and perfection of the foliage, and that anything that interferes with the full development of the leaves and their perfect health prevents the full maturity and perfection of the fruit.

10. Classification of Fruits.

Botanists have classified all plants according to various degrees of relationship into what is called the Natural System. It is not necessary here to enter into any extended explanation of botanical classification. In a general way it may be said that all plants which form their flowers in one way are grouped together and called an *order*. Within each order are found certain groups of plants, the members of which resemble each other closely, particularly in the structure of their fruit, and differ from other groups in the same order. Each of these groups constitutes a *genus*. Each genus is made up of species, differing from each other in minor points, and seem to have come down from one common ancestor. We find some differences in species, but not enough to make them new species, and so we simply call them *varieties*. The limits of species are very uncertain, for if the plants we call varieties had been first found and named, it is probable that some we call species would be varieties, rather than species. Species is a term rather for convenience than exactness.

Thus we find nearly all of our common fruits, such as apples, pears, peaches, plums, cherries, blackberries, raspberries and strawberries, all form their flowers on the same plan that the wild rose does. Hence, botanists take the rose as the type of the order, and put them all in

the rose order. But it is evident to the most casual observer that these fruits naturally arrange themselves in groups differing widely from other groups in the same order, and make various genera in the rose order. Thus the genus in which we find the apple, pear and quince is called the Pyrus genus, and that which includes the peach, cherry and plum is called the Prunus genus, while the blackberry and raspberry are in the Rubus genus, and the strawberry in the Fragraria genus. But while these various fruits are near enough alike to be included in one genus, the apples, pears and quinces evidently differ from each other in other respects, and we separate them into species. Thus the apple belongs to the Malus species, the pear to the Communis and the quince to the Cydonia, and the full names will be Pyrus Malus, Pyrus Communis, and Pyrus Cydonia. In like manner the cherry is Prunus Cerasus, the peach Prunus Persica, the specific name and the generic name being both needed to distinguish the plant from others. Then, in our cultivated apples, we find that while all have probably descended from the original Pyrus Malus, they have taken on a great number of characters in color, size, shape and quality, and while still all belong to the same genus and species, we distinguish them by the common names, such as Baldwin, Pippin, Greening, etc.

Any one can see, then, that botanical classification, instead of being the puzzle that some seem to think, is only a simple, systematic and natural way of arrangment by means of which we are enabled to get at the relationships of plants, a knowledge of which will prevent our falling into errors and superstitions. Through it we learn the probable limits of crossing, hybridizing, and the stocks best suited for grafting or budding each species upon, and can better study the laws of their development.

11. Nursery and Orchard Classification.

While a knowledge of botanical classification is important to the orchardist and nurseryman, and each should be to some extent familiar with the botanical names, we have, as a matter of convenience, a different method of classifying our fruits. Those which are classed in the apple genus are commonly called pomes, or kernel fruits, pome being the term used to describe the particular way in which the fruits of apple, quince and pear are formed, and from this we get the word pomology, as including the study of fruits in general. The stone fruits, like the peach, plum and cherry, have what are called drupes, but in the language of the orchard we speak of kernel fruits and stone fruits, and neglect the names pome and drupe. Then the gooseberry, currant, blackberry, raspberry and strawberry are gathered together under the common name of small fruits, and are called ber-

ries, though the botanist would call only the gooseberry and currant strictly berries. Grapes seem to form a class by themselves, being neither small fruits nor orchard trees, but in the strictest sense vines, though in this country we are apt to call any running stem a vine, while, strictly speaking, there is but one *vine,* the grape.

II.—THE PROPAGATION OF ORCHARD TREES AND VINES.

1. Why we Graft and Bud Fruit Trees.

It is common to hear people say that most of the difficulties we have in the production of fruit trees are due to the fact that we use grafted and budded trees. They insist that fruits grown from the seed are more healthy in the tree, longer lived and better. This idea is generally held by people who are unacquainted with the improved varieties and their superiority over the old seedling trees of their boyhood. It is probably true that the old seedlings endured more neglect and abuse than the improved varieties of to-day. The further we remove a plant or an animal from its natural wild state, the more they need the fostering care of man. Highly bred cattle need more attention than scrubs, and highly bred fruits need more care than the wild crab. The wild peaches will grow along our fence rows and seem to hold their own more free from disease than others, but the insignificant fruits they bear have little resemblance to the improved sorts in the nursery lists. It is true that by the selection of seed from fine fruits we may reasonably expect to produce some fine peaches from the seed, but the majority of the seedlings will show a tendency to revert to the original wild type. We have already said something in regard to the ease by which the blossoms of the trees are cross-fertilized by bees and other insects in the orchard, so that there is little probability that a tree raised from such seed will resemble, to any great extent, the fruit from which it came. It is said that the noted Elberta peach was only one of a thousand seedlings which the grower thought worth of increasing. While, for home use, seedlings carefully selected may answer very well, if we are growing fruit on a commercial scale, we *must* use budded or grafted trees, since in no other way can we exactly reproduce the varieties we want, and which have a reputation and are known on the markets. Suppose that a man raises one thousand peach trees from seed and plants them in an orchard for the purpose of shipping the fruit. When they came into bearing he would probably have early sorts, late ones and midseason ones scattered promiscuously here and there,

some white fleshed, some yellow, some freestone and some clings, some good but most of them inferior to the sorts already grown. When his heterogenous collection goes to market and the dealers are told that they are simply seedlings without a name, that fact would at once cut down the price, no matter if the fruit was fairly good, for the dealers want known sorts only at the market price, and the seedlings will sell only when the market is bare of good fruit.

Then, too, with the varieties scattered promiscuously over the orchard he would have to go over the ground repeatedly day after day to hunt them up, and thus add a great deal to the expense of gathering a low-priced article. But if he uses budded trees of the standard varieties, he will plant all the earlies in a block to themselves, and so on in succession through the orchard, so that at one going over he can gather the crop of each in succession, without loss of time and labor. There would also be enough of one variety to make a shipment and they would go to the market under names known to the trade and bring the market price.

It is not, then, a question as to whether budded or grafted trees are more healthy or long lived. It is a simple business proposition, for if you want to grow fruit for the market, you must grow standard sorts that the market wants and knows, and to have these you *must* use the budded or grafted trees. There is no profit in shipping seedling fruit to market in competition with the standard varieties from commercial orchards planted by those who know their business, and this fact should be fully understood by those who purpose to grow fruits for shipping. The mountain region of Western North Carolina is naturally the finest apple region at least east of the Mississippi River, but there are thousands of trees there of seedling varieties, good, bad and indifferent, which will never make profitable orchard fruits because totally unknown to the dealers elsewhere, and necessitating by their variety the packing of different sorts in one package, to the detriment of the whole. If the apples of North Carolina are to make a reputation, as they should, on the market, there must be a more intelligent planting of orchards of standard sorts which the market wants. The towns of the State are supplied with well-packed and assorted Northern apples simply because the varieties wanted can not be had in the State in as good shape, and because our people in the apple sections have not learned how to handle and pack their apples for the market in the proper manner.

The natural method of increasing any seed-bearing plant or tree is from the seed, but in our cultivated fruits we have gotten away from the seedlings, except for the purpose of growing stocks or roots on which to place our improved varieties. Some, of course, who are engaged in the production of new varieties, use seed that have been produced by the artificial crossing of varieties having characteristics

which they hope to combine in a new sort, and from the seedlings thus grown they select here and there one among the thousands that they consider worth grafting or budding for reproduction.

2. Artificial Methods of Propagation.

The increase of the standard varieties of fruits by artificial methods depends on the division of the original plant in some manner. These separated parts of the original are variously used as cuttings, layers, suckers, buds or grafts.

Cuttings of the Top or Stem.—Grapes, currants and gooseberries are grown from cuttings inserted in the soil to make roots. We have shown that roots are always derived from stems, and not stems from roots. Whatever the foliage is, that the root will be. Therefore, from a cutting we get the identical plant we take it from, no matter whether it is used simply as a cutting to be rooted in the earth or as a graft to be put on another root or stem. Among our fruit trees few are increased by the rooting of cuttings. The Leconte pear and the Marianna plum are increased in this way. Grapes are always increased by cuttings, either long ones in the open ground, or single buds rooted under glass. Of course where it is desirable to change a variety that is undesirable for one that is wanted, the cutting may be used as a graft on an old established root. But this grafting is never practiced for the general increase of the grape. Grape cuttings for setting in the open ground should be made from the ripened wood of the last season. They should have three buds or nodes, and should be cut immediately below the bottom bud and an inch above the top one. The time for setting these cuttings in our climate is in the fall. They should be set as shown in the cut, and should have a mulch of pine straw in winter to protect the ground from freezing. Figs are also grown from cuttings, but as the fig is tender, the cuttings should be made in the fall after the leaves fall, and tied in bunches and buried in a dry place out of reach of frost for setting in the early spring. Quinces are also grown from cuttings set in the fall, as the grape cuttings are. We may also add in passing that cuttings of the hardy hybrid perpetual roses can be made in the same way as the

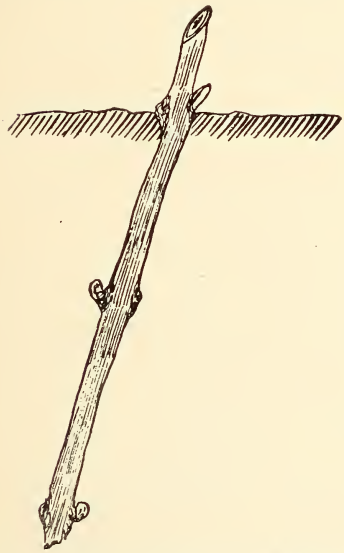


Fig 4. Grape cutting for open ground, showing depth of insertion.

grape cuttings, and set in the fall, in the warmer parts of the State, and will make fine plants the following summer. Some varieties of grapes which do not root readily from long cuttings in the open ground, can be propagated from cuttings of single eyes set in pots or in the sand of the propagating bench of the greenhouse, where a moist bottom heat can be given. These are lifted from the sand when rooted and placed in pots, and later on turned into nursery rows, where they make the finest of plants.

FIG 5. Single eye cutting of grape.

The cut shows how these single-eye cuttings are made and placed for rooting. Cuttings of our Tea roses are made from the young green shoots and inserted in the sand in the greenhouse, as the grape cuttings are. With the grape it is necessary to make the short cuttings in the fall and bury them in the sand outside till a callous forms over the cut, and about the first of February they are set in the greenhouse to root. If placed in the heat at once, the tops would grow before the roots are formed, and the cutting will perish. The green cuttings of the tender roses and other plants must be potted when rooted in small pots, and carried over the winter in frames covered with glass sashes and set in the ground in spring.

Cuttings of the Root.—Many plants, as we have said, have adventitious buds on their roots, and when this is the case, cuttings of the roots can be used for the increase of the plant. Many of our flowering plants grown in the greenhouse can be increased in this way better than by cuttings of the tops. Among our fruits this method is better adapted to the propagation of the raspberry and blackberry than any others. The cut shows a root cutting of the raspberry, which should be two or three inches long. The cuttings are made in the fall and placed in boxes of sand, which are buried in a dry place out of reach of freezing. In the early spring they are planted in well prepared soil and covered two or three inches, and by fall, if well cultivated, will make fine plants and far better than the suckers taken from old plants, as they have a better developed root system. The cuttings may be set here in the fall if in well drained land and protected by a mulch of pine straw during the winter. Of course the suckers that sprout freely around the stems of blackberries and red raspberries can be used for planting, but they are far inferior to good plants grown from the cuttings of the roots, and in buying these plants the purchaser should always insist upon getting root cutting plants. Suckers of some fruit trees are at times used for planting, especially of plums that are on their own roots, but such a method is not advisable. Far better buy a properly grown tree than to use suckers given to you.

FIG. 6. Root cutting of raspberry or blackberry.

Propagation by Layers.—There is hardly any plant that may not be increased by layering. A layer is essentially a young stem of a plant in which an incision is made and the cut buried in the earth while still attached to the parent plant till the roots form. It is then cut off and planted as an independent plant. There are many modes in which this layering is accomplished. One of these is what is called stool layering, and is used sometimes as a means for the production of stocks of the Angers quince and of the Paradise apple, on which to work pears or apples. The stool plants are set in rows far enough from each other to allow of each being treated separately. At the end of the first season the stem is cut back a foot or more from the ground. In the spring shoots start from the buds below, and the earth is then mounded over the plant so that the shoots take root in the mound and are cut off and transplanted at the end of the season. The same stools will continue to furnish shoots year after year. The Paradise stocks are used for dwarfing the apple so as to make small and early fruiting trees for small gardens and for pot culture, as the Paradise apple is a mere shrub, bearing a sweetish apple of inferior quality when not over four feet high. Layering is also practiced with the grape. A long cane of last year's growth can be laid in a trench in the soil near the vine, and pinned fast. When the buds on it start and make shoots above the surface of the soil, the trench is filled with earth and kept clean during the summer. Roots will start from the base of each shoot, and in the fall these can be cut into separate plants and planted where wanted. Layering is probably the best method for propagating the Scuppernong and its kindred varieties of grapes, though a system of root grafting has been devised by a North Carolina nurseryman which we will describe elsewhere. The ordinary way of making a layer is to select a branch that can be bent to the ground. Make a sloping cut vertically half way through the stem and a short distance from the end of the shoot. Place this cut in the soil and bend the top of the shoot upwards and attach it to a stake to keep it in position, while the cut is buried in the soil. By the attachment to the parent plant the shoot will be maintained and roots will be produced from the cut surface, and in the fall it can be severed and treated as a new plant. In layering the fig, take shoots of the same season that spring from the base of the tree, and in the fall make a trench as we have described, and bury the stem in it. In the spring shoots will push through the soil and each will form roots at the base, and can be taken off as an independent plant in the fall or spring following. When this mode is used with the grape, it should not be done till spring, as the grape shoots may not push through the soil. Sometimes a one-year shoot of the grape is prepared in the ordinary way for layering by making an incision in the shoot, and the cut is inserted in a small basket filled with rich soil. The basket

is buried by the vine and the top of the shoot staked erect. In the fall the basket and all are lifted and planted, and thus a larger part of the roots preserved. This method is well adapted to the increase of the Scuppernong grape in a small way.

Propagation by Budding.—In nearly every book on fruit culture the directions are given for taking off a bud as follows: Insert the knife a little way above the bud and take out a shield-shaped piece, with the bud in the centre, and then pick out the piece of wood removed with the bark. A practical budder does nothing of the sort. He takes the stick of buds or the shoot on which they are growing, and from which he has cut the leaves, leaving the leaf stems as handles, in his left hand. He then inserts his knife below the bud and cuts straight upward to about three-fourths of an inch above the bud. Then he cuts square across at this point merely through the bark, and a slight pinch will remove the bud and leave the wood in place. The following cuts show the improper and proper way to cut a bud.

FIG. 7. Improper way to cut a bud out.

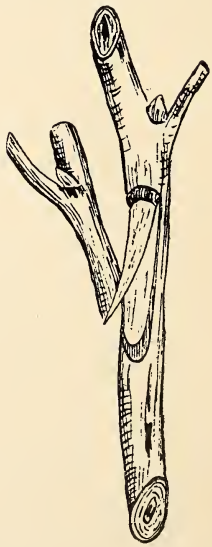


FIG. 8. Bud properly cut.

The buds are thus removed more rapidly, and the top is square for fitting in the incision in the bark. A cut is now made in the bark of the stock, near the ground, in the shape of the letter T. The flaps are turned back and the bud slipped into place and tied with a cotton or bass bark string. The material sold under the name of raffia is now generally used for this purpose. The bags in which Java coffee is imported are made of this material, and can be had cheaply, and are easily ravelled for ties. The lower end of the tie can

be wrapped over and the upper end slipped into a slit made in the stock and tying saved.

Budding is done at such times in the summer and fall as the bark on the stocks rises freely, and the buds are mature enough to work. Pears, plums and cherries come first, and the peach usually last, though the peach is sometimes budded in June and some growth allowed to be made the same season. Budding, in this climate, of the peach is usually done in August, and northward later. The object is to get the buds united to the stock and to remain dormant till spring, when the stock is cut off and the bud allowed to form the new top of the tree. For home use a June-budded peach will answer very well, and a season is saved in the planting.

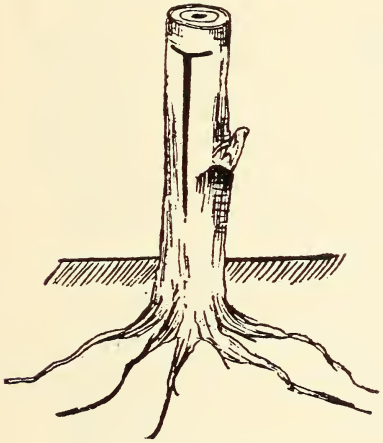


FIG. 9. Cut for inserting bud.

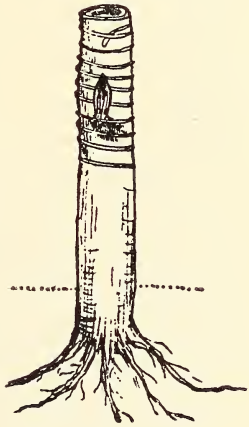


FIG. 10. Bud tied in.

Propagation by Grafting.—Some works on horticulture give numerous methods for grafting, most of which are only useful in certain contingencies or for certain special purposes. In general there are two methods of grafting used in the growing of our ordinary orchard fruits. One method is what is called cleft grafting, and the other is the whip and tongue graft. The first method is used mainly in top grafting established trees, in order to put a new variety on an old stem. The second is the general method employed in nurseries for the propagation of apples by grafting cions on the roots of seedlings grown for the purpose. The success of either method depends on the close connection made between the cambium layer of the cion and that of the stock. Sometimes, in the case of varieties of apples which naturally make a slow and crooked growth, stems of more vigorous varieties are grafted on the root and later are top grafted by the cleft method so as to give the tree a better stem than that which it would naturally make. Then, too, the clef method comes in hand-

ily when one finds vigorous wildings along a fence row, and wishes to put a good variety of apple on them. Top or cleft grafting is done in the spring, just as growth is about starting. Whip and tongue grafts are made during the winter, buried and set in the nursery rows in the spring. The cuts show the method of cleft grafting.

FIG. 11. Stock prepared for cleft graft.

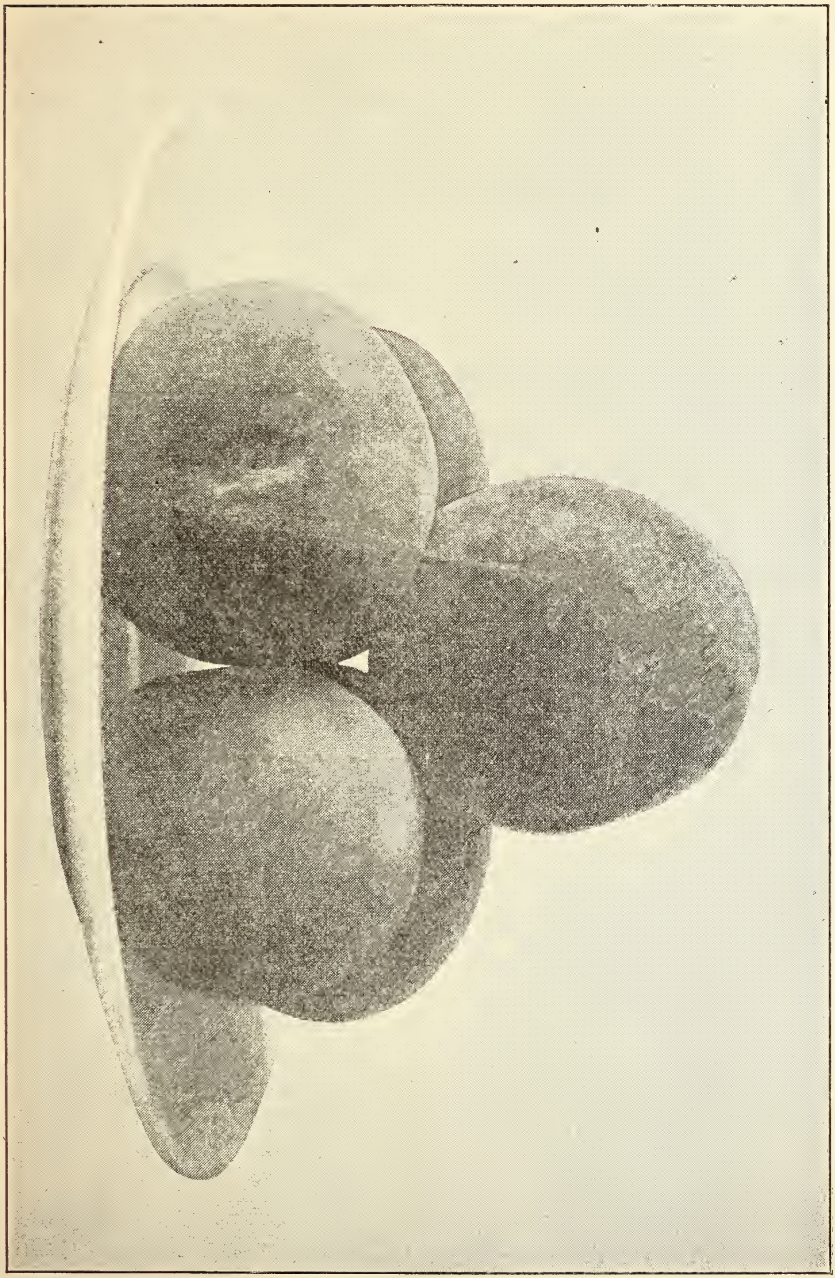
FIG. 12. Cion cut for cleft grafting.

FIG. 13. Graft inserted.

The cions for grafting should be cut in the fall after the leaves drop, and buried in bundles in a dry place outdoors. If to be used for top or cleft grafting, they should be inserted just as the stock is swelling its buds, and the cion being still dormant from being kept cool, will not swell its buds till a partial union is made with the stock. It is therefore far better to have the cions dormant and the stock swelling. The stock to be grafted may be an old tree in the orchard on which a new variety is wished, or it may be a wild young tree along the fence row. An entire new head can be placed on a tree in the orchard by cutting back the branches uniformly above the crotch of the branches, and inserting one or more grafts in each limb. In grafting large limbs it is best to put in two grafts and leave a wedge of wood in the split to keep the pressure of the limb from crushing the graft. In the small young stock cut it off square just where you wish the head of the tree to start. Split the stem as shown in the cut, and shape the cion to fit, leaving two or three buds on the cion. Place the growing tissues of the graft and stock as nearly in contact through as long a space as possible, and then cover the cut end of the stock and cion with grafting wax to exclude water and air.

Grafting wax for root grafting in the house in winter can be made by melting together—

One pound beeswax.
One pint boiled linseed oil.
One pound rosin.
After melting, soak the ties in it while hot.



PEACH—CRAWFORD.

For outdoor grafting melt together—
One pound beeswax.
One pound tallow.
One pound rosin.

Where no wax is at hand and only a few grafts are to be made, make a soft putty of fresh cow dung and smooth clay, and place this around the graft, wrap a piece of oiled paper around it, and tie. There is no better grafting wax made than this, but when much grafting is to be done it is rather unhandy and cumbersome. In making the wedge-shaped cut on the end of the cion, it is best to make it sloping inwards, so as to fit better in the circular stock, and a bud on the cion right at the point of union is an advantage.

III.—THE PEAR.

Propagation.

Two kinds of stocks are used in the propagation of pear trees. Seedling pear stocks are used for standard trees, and the Angers quince for dwarfing the trees. Dwarf trees are not much used now, the early fruiting varieties on their own roots being more largely grown. In some parts of the South cuttings of the Leconte pear are rooted and used for stocks. Seed for growing seedlings for budding are imported mainly from France and Japan. The Angers quince stock are grown from stool layers and from cuttings like the Paradise stocks for the dwarfing of apples. Only a few varieties of pears are perfectly successful on the quince stock, and some entirely refuse to grow on it. Of late years the only pear largely grown on quince roots is the Duchesse d'Angouleme. Most varieties of pears, when worked on the quince stock and not allowed to overbear, will gradually develop into standard trees by the growth of the pear roots, since the sap water brought up by the roots is elaborated by pear leaves, and the growth is essentially pear and not quince, where no quince shoots are allowed to grow. The pear is also worked sometimes on the Mountain ash, which is not a true ash, but a member of the same botanical family with the pear. There has not been found any particular advantage in the use of this stock.

Planting and Cultivation.

The pear prefers a level, deep loamy soil, and reaches the greatest perfection in the eastern section of this State, though thriving in all sections. Owing to the early bearing and thriftiness of the trees, the Kieffer pear has been planted almost to the exclusion of the finer

pears in this State, but all the pears will do well if properly treated. What has been said in regard to the planting of the apple (Bulletin 82) will apply equally well to the pear tree. With the exception of the Kieffer, it is hard to get yearling pear trees of sufficient size for planting. Yearling Kieffers, however, are always of fine size. The Kieffer tends to make very long shoots and to break down from the load of fruit. Hence with this pear it is desirable to train the trees into a different form than is usually seen. Instead of heading the trees back to twenty inches, we would preserve the central stem fully five feet high, and would stake it in an erect position. Then as growth begins in spring we would allow the branches to begin about twenty inches from the ground and take them off in a horizontal position at suitable distances up the stem. Then, by careful summer pinching, we would train the tree into a pyrimidal shape from the one central stem, and would never allow the limbs to get so long and willowy as we usually see them. Trained in this way the tree will carry its crop better and keep in shape longer. Pears, like apples, should be well and shallowly cultivated during the early years of the orchard, and then laid down to grass in the same way as the apple orchard. Heavy manuring with stable manure and deep cultivation tend to a rank, sappy growth, which is far more liable to suffer from blight than a more moderate growth. The fruit should always be gathered as soon as it will part readily from the stem, and should be ripened in a dark room. Pears packed in woolen rags or blankets in a dark room attain a higher color than under any other treatment. Since the pear blooms earlier than the apple, the exposure of the orchard is of more importance than in the case of the apple, and in our climate should not be planted in a warm and sunny exposure, but on a north slope or fully exposed place, so as to be retarded in blooming in the spring. In planting a pear orchard it is a good plan to lay off the land thirty feet each way, as for the apple, and plant the standard trees. Then midway of these plant some of the varieties that do well on the quince stock for early fruiting and to be cut out when the trees get to crowding.

Varieties.

More of the finer varieties of pears will flourish in the mountain section than in the region east of the Blue Ridge, where growers have gradually come down almost exclusively to the Kieffer and other pears of Chinese origin. Not that pears of all kinds will not flourish all over the State, but the Chinese varieties flourish and produce fruit with less care, and as the usual practice is to give little care to fruit trees, those needing more attention have dropped out. But there is no doubt that in the mountain country all the varieties grow more freely and produce better crops than in the lower region.

Duchesse.—This is the only pear we would always grow on the quince stock. On this stock it is a very large and showy pear of very good quality, but on the standard pear stock the fruit is worthless.

Bartlett.—The most popular and best known pear in the country. Flavor peculiar and much liked by most people. An early bearer, but a slow and crooked grower. It makes a better tree if top-worked on the Kieffer.

Manning's Elizabeth.—A small, round and very early summer pear. Profuse bearer and fairly good quality.

Clapp's Favorite.—One of the largest and best summer pears. Growth vigorous and tree productive when once in fruit.

Kieffer.—Supposed to be a cross between the Chinese sand pear and the Bartlett. It has something of the Bartlett shape, but is of much larger size. This pear has caused a great deal of discussion, some declaring it worthless and others praising it. The fact is that it is a far better pear in the South than it is in the North. From Virginia southward a well-ripened Kieffer is a pear of very good quality, and from its great productiveness and early bearing it is becoming the most largely grown pear in the South, and will be largely used by the canners in the future. In a properly arranged fruit room the Kieffer may be kept till Christmas.

Leconte.—A pear of a similar origin to the Kieffer. It is, however, an earlier pear than the Kieffer and a far more worthless one. Some Southern growers have approved the Leconte, but in my experience it simply serves to show how poor a thing a pear may get to be and still be a pear.

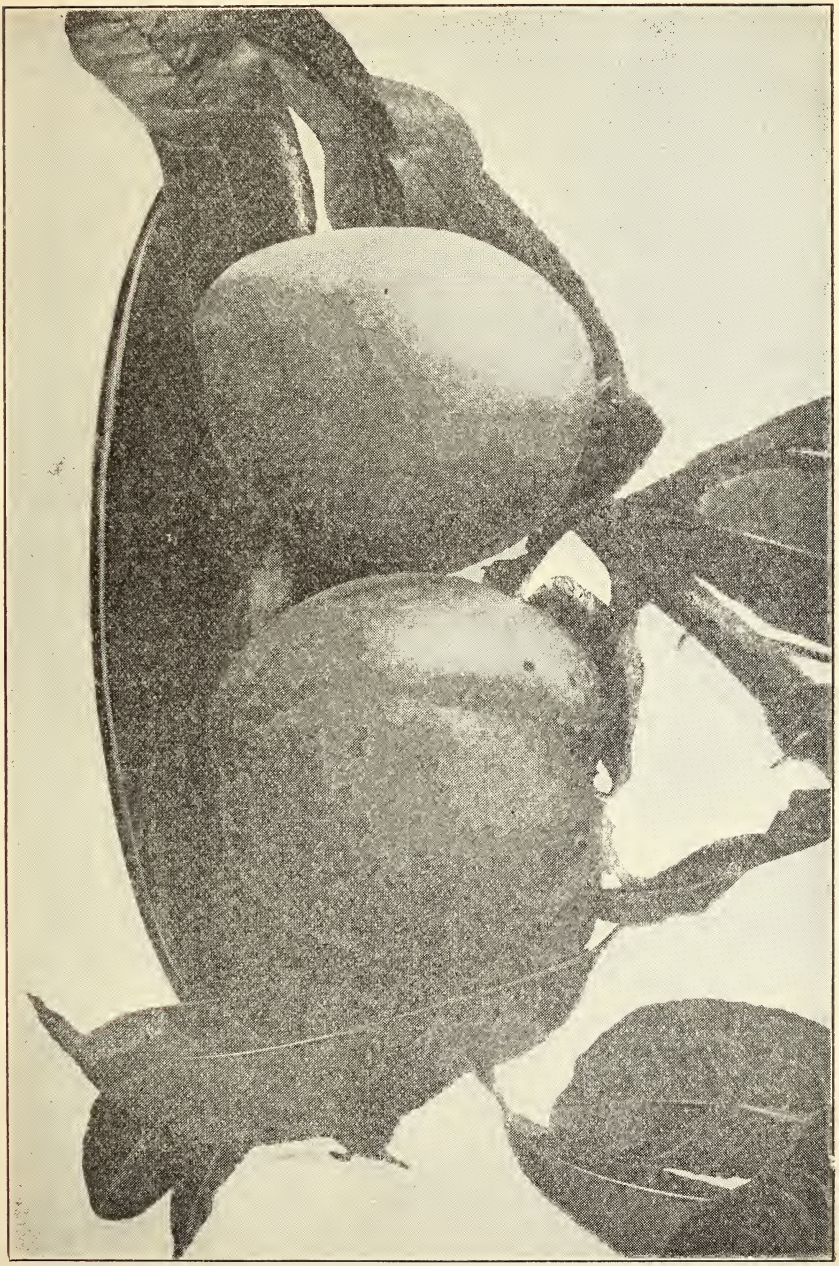
Garber.—Another pear of the same class, and no better than the Leconte.

Seckel.—A small russet pear of high quality and very popular. Tree is a symmetrical grower, but not a rapid one, and is rather slow in coming into bearing. Less liable to blight, in my experience, than any other pear.

Sheldon.—A round russet pear of good quality. Tree needs careful pruning to make it take on a more spreading form, as it naturally grows as erect as a Lombardy poplar. It is a late fall variety.

Easter Beurre.—Probably the best winter pear, when well grown and carefully ripened. Requires rich soil and high culture, and is worthless otherwise.

Vicar of Wakefield.—This is a peculiarly long pyriform fruit. A late winter variety, a good keeper, but of very inferior quality. Tree a very luxuriant and erect grower, and usually healthy. Hardly worth growing.



PEACH—CONNETT'S EARLY.

Packing Pears for Market.

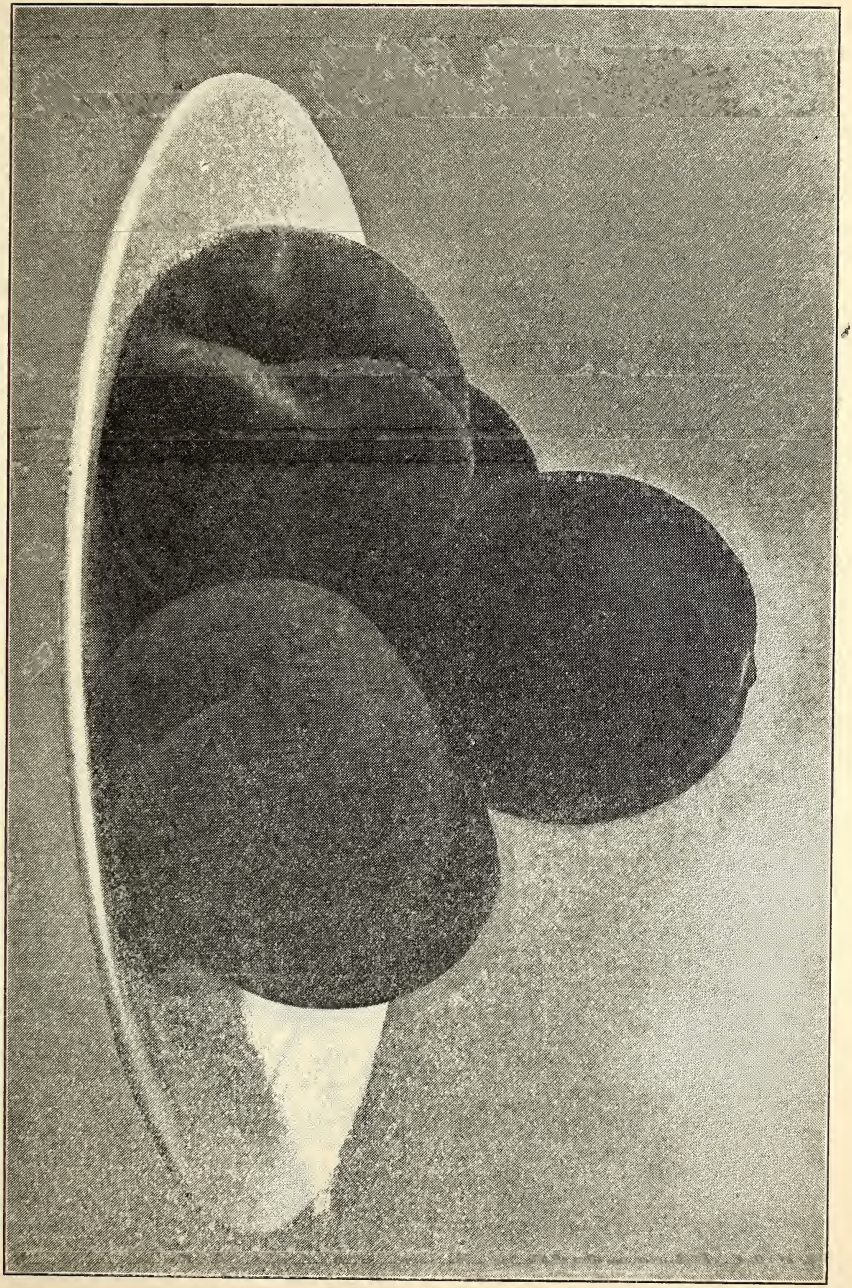
Kieffer pears can be packed while still hard in the same way that apples are packed. Fine pears should be packed in crates made of dressed material and nailed very closely to avoid cutting the fruit. Crates of the bushel size with a central partition like those used in vegetable shipping, except being nailed close, are the best for good pears. But extra fine ones can be shipped in the "Southern Carriers," holding half a dozen baskets, and in this way will be handy for the retailer. The fine pears from California are packed in flat boxes, each pear being wrapped in soft paper and placed closely in the box so that they can not move. Growers of fine fruit should study the methods of packing used by the California growers, for no fruit gets to market in finer condition though travelling thousands of miles.

IV.—THE PEACH.

Propagation of the Peach.

The stock commonly used for the peach is the seedling peach. Plums are used to a limited extent, as some think they are better for a heavy clay soil where the peach roots do not thrive. Most nurserymen make a great point in getting seed from natural or seedling trees to grow their stocks. But this is of far less importance than the getting of seed from healthy trees. We would rather have seed from healthy budded trees than the stock usually collected from the stunted fence row trees. One of the longest lived and most successful orchards in Maryland was budded on stocks raised from seed of budded trees, care being taken to select seed for stocks of early varieties from healthy trees of an early variety, and so on. When this orchard finally wore out, the owner had a large newel post made for a grand stairway in his new mansion from one of the stems, showing the massive proportions of the trees.

Seed for planting is usually stratified with sand in beds in the open ground in the fall, and allowed to remain during the winter to burst the shells. The sprouting kernels are then planted in the nursery rows. Sometimes a few are budded in June and make growth the same season, but the general practice is to bud in August or September, when the buds will remain dormant during the winter, and the seedling tops are cut off and the buds allowed to form the future tree. The buds are inserted as near the ground as convenient and in the manner we have heretofore shown. Raffia is the material generally used for tying the buds, being soft, flat and cheap.

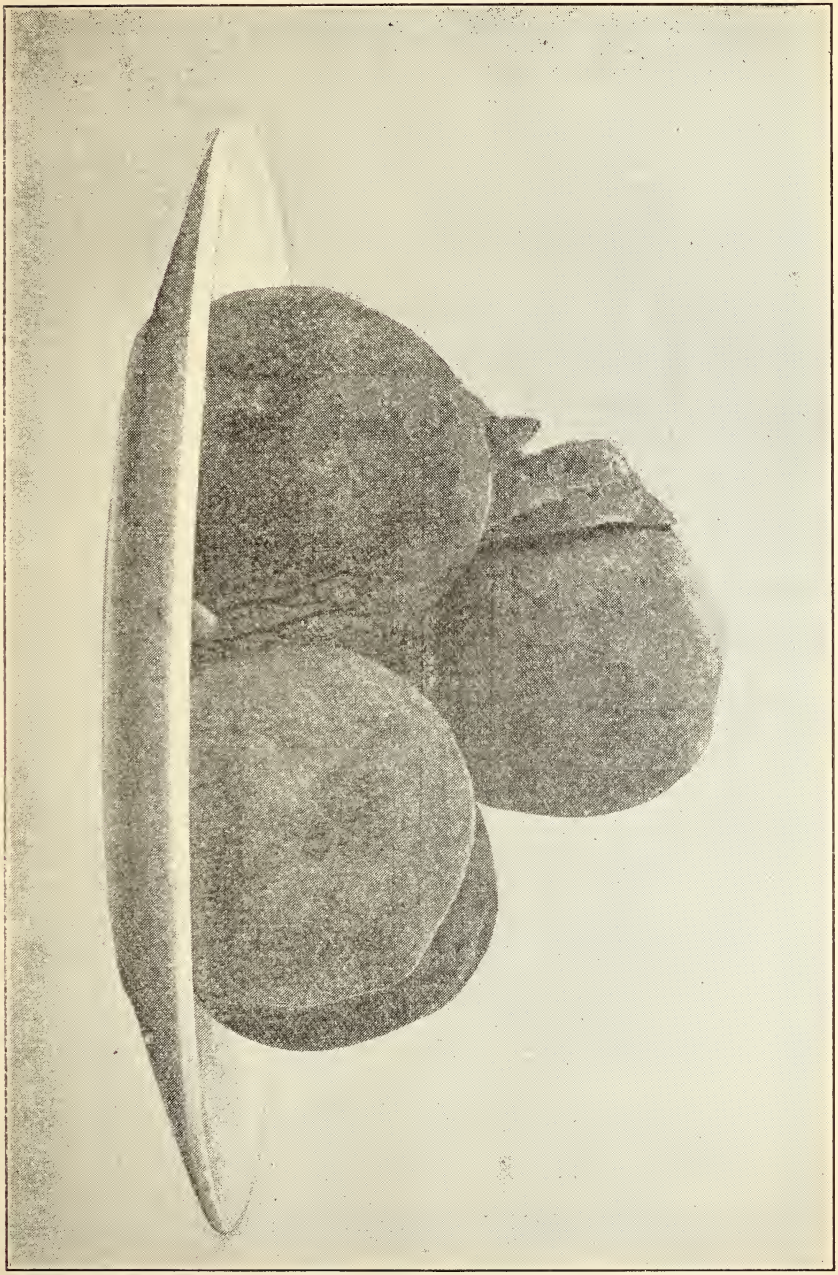


PEACH—HAYNES SURPRISE.

Planting and Pruning.

Peaches should always be set in the orchard after one season's growth in the nursery. One that has been left during the second year in the nursery is practically worthless for planting. In planting, the same care in trimming the roots as advised for the apple should be used. This, in fact, applies to any tree planted. Peach tree roots we always prune back to about four or five inches long each. After the trees are set, using the same careful ramming of the soil as advised for the apple, trim off all side shoots and shorten the main stem to twenty inches from the ground. The great advantage of this low heading comes from the fact that the short stem is soon shaded by the top, and during the first season it is easy to protect it from the sun by setting a shingle on the southwest side. The many advantages of low-headed trees are so obvious that it seems odd that people commonly train their trees to tall stems. The peach trees especially should be low-headed, so that no ladder is needed to gather the fruit.

The best soil for the peach is a rather sandy one. In fact, better trees can be grown and better fruit produced on poor deep sands with fertilization than on the best of heavy clay soils. Commercial peach orchards are rarely successful on heavy clay soil. After planting and heading back, the next attention needed will be when the trees start in the spring. Select three or four buds near the top to form the head, and keep all others rubbed off. If during the summer one of these shoots threatens to outgrow the others, pinch out the tip of the shoot and thus check its too rapid growth. At the next spring's pruning, shorten back one-third of the previous year's growth, cutting carefully to a wood bud pointing in the direction we wish the new growth to take. All interfering and superfluous shoots are taken out, but care is taken to keep a supply of the young wood well distributed through the tree. Peach trees which are allowed to take their natural course soon get long bare limbs near the body of the tree, and have all their young one-year wood, the only kind that bears fruit in the peach, out at the ends of the limbs. The consequence is that when the tree bears a heavy crop the weight at the ends of the long limbs is such that the tree splits down and is ruined. Hence we annually shorten back some of the young growth, and try to keep up young shoots all through the tree, so as to distribute the weight of the crop evenly over the tree, and thus prevent the breaking of the limbs. An orchard pruned in this way will have plenty of room if set 16 feet apart each way, while on strong clay soil it may be better to plant them 20 feet apart. This shortening back should be kept up all through the life of the tree, for the peach is not a long-lived tree, and needs regular cultivation and pruning at all times.



PEACH—TRIUMPH.

Cultivation.

To give the best results, the cultivation of the peach orchard should be as clean as that of the corn field. This does not mean that it should be deeply plowed, for after the first deep preparation of the soil only use a light plow when plowing is needed, and during the cultivation of the orchard only the ordinary cultivator. While the trees are small, a hoed crop may be grown among them, but after the second year the cultivation should be of the trees alone. Cultivation should stop in July, and a cover crop sown. Cow peas sown broadcast take too much moisture from the trees in summer, but two or three rows planted between the tree rows may be allowed to grow till September, and then the whole land should be sown to crimson clover. This is to be plowed under in the spring for the benefit of the trees, and the cultivation renewed. We always prefer to use rope traces in the working of the peach orchard. These are attached to short singletrees through a deep groove around the end of the singletree and fastened by a knot in a staple behind the singletree. In this way should a trace strike a tree it will slip by and do little harm, while an ordinary chain trace with projecting singletree will ruin every tree it strikes. The turning under of the clover annually will keep the trees in healthy growth, but the addition of acid phosphate and kainit will be an advantage to the perfection of the fruit. Five parts of acid phosphate to one part of kainit will answer if used at rate of 400 pounds per acre.

Varieties.

New peaches are continually brought out, but the following list will cover the season very well:

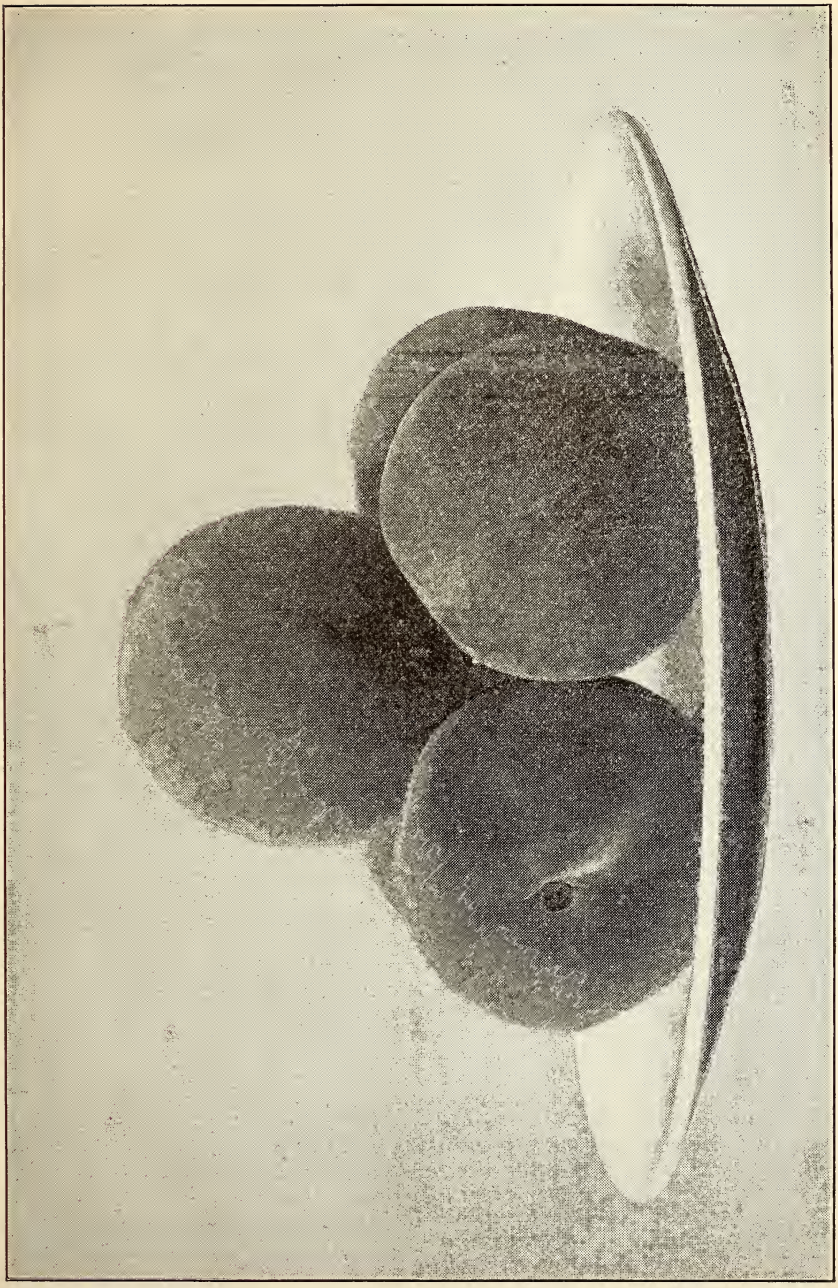
Sneed.—This is the earliest peach grown, ripening at Raleigh about the last of May. It is very variable, being a fairly good peach in some seasons and in others of little value or beauty. Southern growers claim that it pays well as a market fruit by reason of its earliness.

Triumph.—The earliest of yellow peaches. Skin red all over. More subject to rot than any peach in my experience. It may have value on some soils, but it is worthless here. In fact, I may say that in the red clay soil where I am obliged to grow peaches, no variety has as yet come up to the standard elsewhere.

Alexander.—This is about the standard early peach. It is identical with the Amsden. Has the same fault as most of the extra early peaches of adhering to the stone and getting soft from the outside.

Crawford's Early.—A much finer peach than the last named peach.

Crawford Late.—A much finer peach than the last named. Rather late, but large and of fine quality.



PEACH—CRAWFORD.

Elberta.—A very showy and popular midseason peach, more largely grown for market than any other on the list. Good, but not of the highest quality. Its size and rich color make it a very saleable peach.

Mountain Rose.—Medium early, fair size and fine quality. A good saleable peach.

Oldmixon Free.—In my opinion the finest quality in a peach. Flesh white, very rich and juicy.

Susquehanna.—The most showy yellow peach grown, and larger than Elberta, but a very shy bearer.

Ward's Late Free.—A large, white-fleshed and good peach. Ripens about the first of September.

Beer's Smock.—One of the most profitable September peaches, as it is popular with the packers. Not a high quality peach, being dry and mealy, but is very good for canning.

Ringgold's Heath.—The finest of the heath peaches. Cling, and popular for preserving and canning.

Lady Ingold.—A rich colored peach, a little earlier than Elberta, and a profitable peach.

Greensboro.—This is an early peach, a trifle later than Alexander, but larger than that variety. The largest of the extra early peaches.

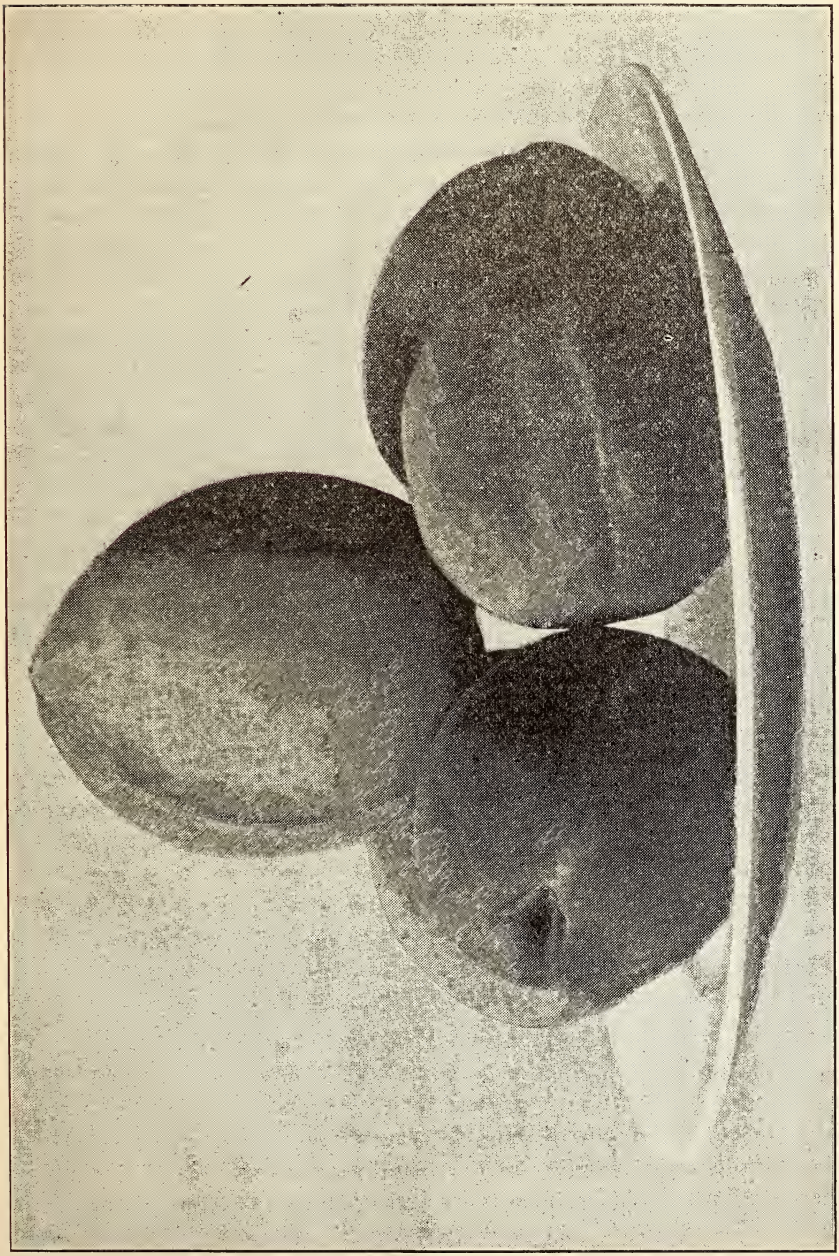
Packing Peaches and Plums for the Market.

These are packed by the California growers in flat boxes and wrapped in paper. For our purposes the Southern Carrier is about the best package. They are light to handle, and the separate baskets make the retailing easier. Peaches and plums must be picked as soon as well matured and colored, and before getting soft. No soft fruit should go in the packages, but all should be well colored. Never pack fruit that has fallen from the tree on the ground, but gather all carefully by hand and assort with care, putting only one variety in the package, and marking the name plainly on the outside. If any cullings are shipped, mark them cullings.

V.—THE PLUM.

Propagation of the Plum.

Plums may be budded on plum seedlings, but nurserymen now generally use the seedling peach stock. The Marianna plum grows readily from cuttings, and is often used as a stock for heavy soils. On most of the light soils of the South the peach is probably the best stock for the plum. Plums are now grown in a number of classes. The finer plums belong to the Domestica or European class of plums. The cultivation of these has been rather difficult in this country, owing to their liability to the attacks of the curculio and to



PEACH—BELLE OF GEORGIA.

rot, and only those who have given especial care to guard against these have done much with the European plums. The methods used will be treated on in the chapter on insects and on plant diseases.

Of late years there has been a great deal of interest in plums, owing to the efforts being made to improve the various types of American plums and to the introduction of the Japanese plums. The first American plum to attract general attention was the variety called the Wild Goose. This has been largely planted because of its ability to resist the attacks of the curculio. The Japanese plums are free growers and good croppers, and while lacking the fine quality of the European plums, they bear crops with less care than the European. Some of them are fully as liable to rot as the European, but their introduction has marked a new era in the cultivation of the plum in this country. Then, too, the strides that have been made in the improvement of the native American varieties have given us many that are very useful additions to the list. A list of the best varieties will be given in the chapter devoted to descriptions of fruit varieties.

Planting and Cultivating.

What we have said in regard to the planting of the peach will apply equally well to the plum, with the exception that the plum will thrive in a heavier clay soil than the peach. But when budded on the peach it is well adapted to our lighter soils, and is being successfully grown in the sandy soils of the long-leaf pine section. One thing is to be guarded against in the planting of plums. Never plant an orchard of one variety alone, for the plum does not set fruit freely with its own pollen. It is best to plant alternate rows of the different varieties, so that complete cross pollenation is secured. We have known orchards of the Wild Goose plum very unproductive from this fact.

While the plum should have during its earlier years good cultivation, the best use that can be made of a plum orchard is to make a poultry yard of it so that the fowls will have a chance to destroy the curculio. Regular jarring of the trees daily to throw the insects and the bitten fruit on the ground where the chickens can get at them is one of the best means for keeping the curculio down. The insects soon seem to get wise enough to avoid trees where the chickens run. It has been noticed, too, that where plum trees are planted along the margin of a pond that the limbs hanging over the water are seldom attacked by the curculio, as the insect seems wise enough to know that the fruit dropping into the water would be destroyed with their eggs on it. Regular jarring and gathering the insects either by hand or chickens will insure a crop free from the curculio, and the price of fine plums warrants all the care needed. In pruning the plum, we

practice about the same method we do with the peach, but when the trees come into bearing it is best to keep the ground around them clean and unbroken, so that the insects can easily be gathered up from the jarring, and the trees, if kept fertilized, will do fully as well in the uncultivated soil. No plum is proof against the attacks of the curculio, but our native sorts do not seem to hatch the eggs like the foreign ones do, and the bite of the insect is apt to heal up. Since the curculio is a sucking insect, no spraying is of any avail to destroy them. The rot is the worst disease, and will be fully treated under the proper head.

American Varieties.

There are a large number of American varieties of plums grown and offered by the nurserymen. We have tested a number of them, and find that few are worth growing for the market. The following variety has proved about the best for market purposes of all the American sorts.

Wild Goose.—This variety is now well known. It is of a bright red color, fair size and quality. Ripens in June before the rush of peaches, and generally sells well.

Quite a long list of plums is offered in the catalogues, and the industrious improvers may yet produce some superior varieties. They all have the peculiarity of being better ripened after maturity if gathered and placed in the house than if left to ripen on the tree. In the market none of them so far can compete with the more showy and better European and Japanese varieties, but the fact that they withstand the attacks of the curculio and the rot better than other kinds should lead to further experiments in their improvement in other respects. The most promising varieties of this class at present are De Soto, Hawkeye, Milton, Pottawattamie and Robinson.

Japanese Varieties.

Some of these, such as the Kelsey, may be tender in the high mountain country.

Abundance.—This is one of the hardiest of these plums, and probably the best one for the North and the mountain region South. It is large and showy and a most prolific bearer. Ripens the last of June.

Red June.—This will probably rank next to the Abundance in hardiness and productiveness. It is earlier than Abundance, of fine size and a dark red color. Some consider it the best of the Japan plums.

Burbank.—This ranks among the best market varieties. It is later than Abundance, very hardy, and the fruit is of large size and of a handsome red color. Quality the best of its class.

Apple.—This is one of Mr. Burbank's seedlings in California from the Japanese strain. It gets its name from its round apple shape. Deep reddish purple in color, and ripens later than Abundance.

Climax.—Another of Mr. Burbank's Japan seedlings, and claimed to be his best. The fruit is much larger than the Burbank, or about the size of an ordinary peach. Dark red in color and of fine quality. It is among the earliest. The tree is a remarkably strong grower.

Kelsey.—This is one of the finest of the Japan plums, but being a very early bloomer, the crop is uncertain. It is also rather tender in cold localities. Fruit large and pointed. Ripens in September.

The catalogues give a number of other varieties, but these are probably the cream of the class.

European Plums.

These are the finest plums grown, but owing to the ravages of the curculio in this country, the Japan and the American varieties have been commonly planted in their place. Where due attention is given to the jarring of the trees daily and the catching of the curculios, fair crops of fine fruit can be had. The varieties are very numerous, but the following may be regarded as the standard sorts:

Bradshaw.—Large, dark red; good for market. Ripens in August.

Diamond.—A new variety of very large size and of a dark purple color. Tree vigorous and productive.

German Prune.—One of the oldest and most certain bearers in our climate. Of fairly good quality. Dark purple in color.

Imperial Gage.—Larger than the old Green Gage, which has always been considered the standard for plum quality. Color pale green.

Fellemberg.—Largely used for making prunes of large size. It is a very large plum of good quality and productive.

Shropshire Damson.—Generally considered an improvement on the old damson, but in our experience is less productive. Rather larger in size than the old damson. The common damson, if given due attention, will prove one of the most profitable plums that can be grown here.

VI.—THE CHERRY.

Propagation.

Two kinds of stocks are used for budding the cherry on, the Mazzard and Mahaleb. The Mazzard is generally preferred in the North and makes the largest tree. But in the South we would prefer the Mahaleb stock. In the warmer sections of this State, east of the

Occoneechee hills, none of the finer cherries can be grown with any success, while the Duke and Morello classes do fairly well. In the upper part of the State the cultivation of fine cherries for the Northern markets ought to be made very profitable if handled and packed in the same attractive manner used by the California growers. Handled in this way there is no reason why North Carolina cherries from the upper Piedmont and mountain sections should not command a better price even than the California fruit. In fact, in the sections named we believe there is more profit to be made from fine cherries than almost any other orchard fruit, except the apple. Parties unacquainted with fine cherries have of later years been getting people in the eastern part of the State to plant what is called the Amos Owen cherry. We do not refer to the swindling operations in connection with this cherry, but to the cherry itself. It is well known to nurserymen who are acquainted with fruits that the Amos Owen cherry is simply the Black Mazzard, which is used by nurserymen as a stock to graft fine cherries on, and is not a fine table cherry at all. Thousands of these little black cherries have been planted on the line of the Seaboard Railroad, in a section where they will hardly do well, and if they did the inferior quality of the fruit would make it unprofitable for anything but the cherry bounce that is made of it in the mountains. In buying fruit trees of any kind, always deal with the nearest reliable nurseryman, who has a reputation to sustain and who is responsible for what he sells. The larger varieties of cherries should be planted not less than 25 to 30 feet apart each way, while the Morellos will bear planting 15 feet apart, owing to the small size of the trees. The Dukes should be planted as far apart as the hearts and Biggareaus. The Morellos reproduce themselves fairly well from seed. Cherries, like peaches, prefer a light, dry soil, and should never be planted on cold, heavy clay soil till it has been well drained.

Varieties.

Cherries of the finer varieties should be very profitable in the upper Piedmont and mountain sections, while generally useless in the warmer parts of the State, where only the Morellos and Duke cherries thrive.

Black Tartarian.—A large black cherry, one of the best of the color.

Luelling.—Very large, black, and the finest of all black cherries.

Governor Wood.—Very large, yellow and red; a showy and good selling cherry.

Yellow Spanish.—About the best of the light yellow cherries, with red cheek, and a very profitable market sort.

The foregoing belong to the Biggareau and heart class. The following are sour cherries:

Dyehouse.—The earliest of the Morello class.

Early Richmond.—Another early variety of Morello.

Morello.—The common red variety, and the most reliable one in the South.

The so-called Amos Owen cherry is, as we have heretofore said, nothing but the little Black Mazzard, which has been used for generations as a stock for budding the finer cherries on. Parties unacquainted with fine cherries have encouraged the planting of this little black cherry in the eastern part of the State, where, if it succeeds at all, it will be worthless as a market fruit.

Packing Cherries for Market.

Always pick cherries with the stems left on and pack them carefully in the same kinds of baskets and crates that strawberries are shipped in. The finer sorts of cherries, which can be grown well in the western part of the State, should be very profitable if shipped North in good order. Neatly packed in layers in flat boxes, with paper between each layer, are about the best of packages for cherries of fine quality, and it would pay the growers in the western part of the State to adopt this method and get the pound prices for the fruit.

VII.—THE QUINCE.

No fruit has been more neglected than the quince, but it will thrive and repay intelligent care. The trees are easily grown in the South from long cuttings set in the fall, or from stool layers. Train them to short stems like the peach, and do not let them become unsightly bushes as usually seen. When planted in orchards, the quince prefers a moist clay loam, and should be set about fifteen feet apart each way. Give regular cultivation, and when they come into bearing, seed to grass and keep it cut short and let decay on the land to mulch the trees, like the apple and pear. The varieties are few, and will be treated of later.

Varieties.

Orange.—This is the old and well known variety; early and productive when well grown.

Champion.—A newer and larger variety than the Orange, and quite late. Better for the South than the Orange.

Chinese.—Very large oval or lemon-shaped fruit, fine for preserves, and as quinces are generally grown for this purpose entirely, there is no better variety for the South.

JAPANESE PERSIMMONS.

The Japanese Persimmon is of recent introduction in this country, and as yet is not extensively grown. They are too tender for the colder parts of the State, and do not thrive north of Eastern Virginia. It is found, however, that in many places where they are tender while young, if they are protected by banking the soil about the stems in the fall, they gradually become more resistant to the cold as they grow older. They should be worked low on stems of the native persimmon. Some of the varieties make fruit as large as a large apple and very showy, but in quality we have not found them superior to many of our native seedlings. They may either be budded low like the peach, or grafted on the roots of the native persimmon like apples are grafted. Any soil that suits the native persimmon will grow them if the climate is not too cold.

Varieties.

Hiyakume.—This is the largest and most showy variety, and, in our opinion, includes all that are worth growing, since none of these large Japan sorts are equal in quality to our smaller native persimmons.

VIII.—THE FIG.

Some years ago we were quite enthusiastic over fig culture in the warmer parts of the State, and we experimented with a great many varieties, and grew hundreds of seedlings from the dried imported figs. But the class of figs to which these last belong will not hold their fruit here because of the absence of the little insect that in the south of Europe sets the seeds. This insect has now been introduced into California, and they are there successfully growing the Smyrna figs. We had at one time nearly one hundred named varieties of figs, but found that most of them were too tender for our climate, so that we have gradually been narrowed down to two varieties, the Brown Turkey and the Celestial. We have grown figs successfully in Northern Maryland, up near the Pennsylvania line, by growing the trees branching from the ground and bending the limbs down in the fall and covering deeply with earth. But we have found that this method will not do here. They come through our ordinary winters unharmed, but we are apt to have an occasional winter when the cold is so severe as to cut them back badly, and when this is the case the early figs, which are set in the fall, are lost, and only the later ones mature. The best protection we can give them here is to bend the

branches to the ground and pin them fast, and then pile green pine boughs over the whole. In the colder parts of the State the burying and covering with earth will doubtless be as successful as in the middle States, but here the trees covered in this way are apt to rot in the warm and rainy weather we have in winter.

Cultivation.

The fig prefers a level, moist soil, and always thrives better in the immediate vicinity of the salt sea water than anywhere else. Wood ashes and a small amount of salt are better for them than animal manures, which cause too rank and tender a growth. Do not allow the trees to become smothered with suckers from the base, as the best fruit is grown on the short shoots from the older wood. Very little pruning is needed, and this only to keep up a supply of shoots to take the place of old stunted branches. Fruit is formed on the young wood as fast as it grows all summer, and late in the fall as the frost cuts the leaves the young fruit in the axils of the leaves becomes dormant, and will make the earliest fruit in the spring if not killed in winter. There is an old notion that the fig never blooms. This arises from the fact that what we call the fruit is merely the receptacle enclosing the multitude of little flowers inside, and the casual observer, seeing no blossoms, jumps to the conclusion that there are none, while there are few trees which make more flowers.

Winter Protection of the Fig Tree.

We have already stated the best protection for the fig in the middle section of the State. On the coast, in the immediate vicinity of salt

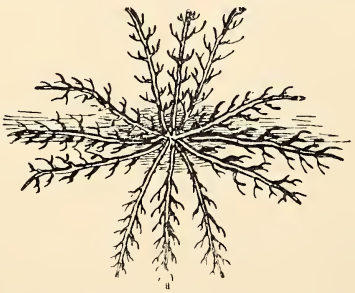


Fig. 14. Fig tree bent to the ground ready for covering.

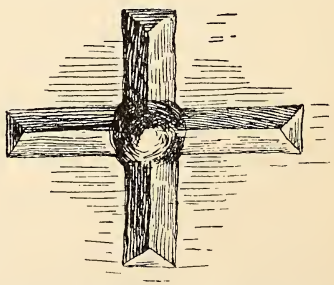


Fig. 15. Fig tree covered with earth.

water, it will need no winter protection. But in the cold western part of the State the method I have found successful in Maryland will do equally well. This is to branch the trees from the ground, and in fall, after the frost has cut the leaves, bend down the branches to the ground and pin them fast, and then pile the earth over them, mound-

ing it over the centre and sloping to the outside so as to throw off the water, or gather the limbs like a cross on the ground and cover each bunch separately with a higher mound in the center like a four-pointed star. They will keep perfectly in cold climates in this way. Here the best way possible, though very tedious and troublesome, is to thatch each limb and the stem thickly with broom sedge, wrapped on with cotton twine. This is the best protection I have ever tried; but the bending down and covering with pine boughs usually answers very well. Where the trees are to be bent down and covered, it will be necessary to plant them twenty feet apart each way, in order to give room for the covering. With the earth cover it is more certain to have good crops of figs in a cold climate than here without protection.

Curing Figs.

The skillful housewife knows well how to make delicious preserves of the fig, but the drying of them is a matter not so well understood. A portable evaporator is needed for the purpose. Many of these are now made, and any kind will answer. The fruit must be cut with the stem as soon as ripe and before bursting. Place them in wire or wicker baskets, and dip in a strong lye made of hard-wood ashes. This is to take the acrid principle from the skins. Then at once dip in clean fresh water to remove the lye. Dry in the evaporator, and when dry pack down for use in jars or boxes. The fig can be canned just as other fruits are, either in tin or glass. A good article of canned or preserved figs in neat glass jars, with attractive labels, will always sell well.

IX.—THE POMEGRANATE.

The pomegranate thrives so well in the warmer eastern part of this State that it is rather surprising that it is not more grown. The double flowering varieties which produce no fruit, but make flowers of bright color and as large as a rose, are grown successfully about Raleigh, and we have seen the fruit-bearing ones ripen here. But the eastern coastal plain is the proper home of the pomegranate. It makes a handsome small tree, the flowers are handsome and the fruit showy. The acid pulp around the seeds makes a pleasant drink and fine jelly. The pomegranate can be propagated by cuttings under glass, by seeds in the open ground, by layers and by suckers from old trees.

Varieties.

Purple-seeded or Spanish Ruby.—Large, yellow, with red cheek. Pulp purplish red. The best variety, and will succeed from Raleigh eastward.

Bulletin No. 185 April, 1903

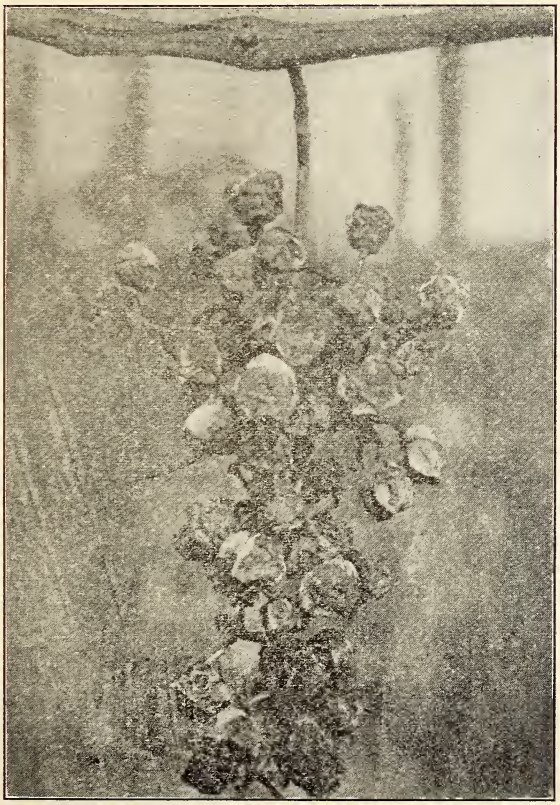
NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.



A source of infection.

The Black Rot of the Grape in North Carolina and Its Treatment.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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The Director's office is in the Agricultural Building, Raleigh; the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

PREFACE.

During the past few years complaints have been numerous and serious regarding the ravages of the "Black Rot" of the grape in the grape growing sections of the State. Large vineyards, particularly of the Niagara variety, were cut down in some sections of the State because of inability to combat the ravages of the rot. As neither the State Department of Agriculture nor the Experiment Station was in position to put an expert in the field to study the disease and make experiments with the view of obtaining methods for overcoming the disease, arrangements were made with the Bureau of Plant Industry of the United States Department of Agriculture, by which the investigations outlined on the following pages were carried out by Mr. A. W. Edson, expert in plant diseases, under the direction of Dr. Albert F. Woods. The expenses of the experiment, outside of salary, were borne jointly by the North Carolina Department of Agriculture and the Experiment Station.

Expression of appreciation is here made of the kindly interest and co-operation of the United States Department of Agriculture in this work, which is of so much importance to this State.

The results are encouraging, and our grape growers will find them of interest and value to their industry.

B. W. Kilgore,
Director.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 20, 1903.

Sir:—I have the honor to submit herewith the manuscript of a bulletin on "The Treatment of Black Rot of the Grape," by Mr. A. W. Edson, of this Bureau. The bulletin describes the work which we have been doing in co-operation with the North Carolina Department of Agriculture and the North Carolina Experiment Station, for the purpose of determining the efficacy of spraying as a means of controlling black rot in North Carolina. The experiments were carried on under the direction of Mr. Albert F. Woods, Physiologist and Pathologist, of this Bureau, the funds being supplied by the two State departments above named. Mr. Edson was conducting experiments in North Carolina on other problems, and at the suggestion of the Director of the Station, it was arranged that he should plan and supervise experiments along the lines already pointed out. In view of the fact that the North Carolina Department of Agriculture and Experiment Station furnished the funds for the work, and that the results are particularly applicable to the region in question, I would respectfully recommend that this bulletin be placed in the hands of the Director of the Experiment Station for publication from his office, he having expressed a desire that this arrangement be made, if practicable.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Approved:

Hon. James Wilson,
Secretary of Agriculture.

Von Herff Vineyard at Southern Pines, N. C.

Vineyard of Mr. R. F. W. Allston, Tryon, N. C., where experiment plots were located

TABLE OF CONTENTS.

The Black Rot of Grapes in North Carolina.

By A. W. EDSON, Bureau of Plant Industry,
U. S. Department of Agriculture.

The black rot, so destructive on both wild and cultivated vines of the Eastern and Southern States, is caused by a fungus, *Guignardia Bidwellii*. This fungus requires for its development, warmth and moisture. The disease appears in distinct waves, of which there are generally two or more in a season, and which are co-incident with, or immediately follow, periods of warm, muggy weather.

The disease first appears on the leaves in small, round spots, about 5 or 6 mm. in diameter, and of an ashy brown. These soon become darker in color and later produce numerous tiny black spore-bearing pustules, about the size of a pin point. These tiny black points are quite visible to the naked eye. Later on the same spots appear on the green berries; probably infection from leaves previously spotted. As on the leaf, these spots are ashy brown at first, then turn darker in color, and put forth the tiny black pustules that bear the spores, the rot then spreading from these spots and destroying the whole berry. Sometimes the entire crop in a vineyard is thus destroyed in an incredibly short space of time. The rotted berries gradually dry up and remain clinging to the vines in a very characteristic manner through the following winter, and even through the spring and summer months. It is from the spores given off from these old dried-up bunches that the infection of the following season is due.

Black Rot in 1902.

During the season of 1902, experiments and observations were made by the Department of Agriculture with a view to the control of the disease. Most of the work was done at Tryon and at Southern Pines, in the State of North Carolina, in co-operation with the North Carolina Department of Agriculture and the North Carolina Experiment Station.

The rot was discovered first at Tryon on the morning of May 14. In the two days preceding there had been frequent showers, followed by periods of hot sunshine with no air stirring. This attack was mostly confined to the leaves on the suckers at the base of the vines. The rot appeared at the same time at Southern Pines, induced, no

doubt, by similar weather conditions. At Tryon there was no material increase beyond what was found the first morning.

The second wave, which likewise appeared both at Tryon and Southern Pines, was less definite in the time of its appearance, and also in its duration. The spell was from May 25 to 30, soon after the grapes were set. Many of the young berries were infected, and considerable damage done.

The third wave, which was much the worst, did not appear at Southern Pines. At Tryon, in one vineyard, it appeared as early as June 20. On June 26, 27 and 28 the rot was very destructive; the damage then exceeding that of all the season previous to that time. There were heavy showers during this time, with very hot days. This furnished both the heat and the moisture so favorable to the development of the fungus.

During the season comparatively little rot was found on the Delawares, Brightons, Catawbas, Concords, Cynthianas, or Lindleys. The Gœthes and Salems were rather badly affected, while the Niagaras rotted worst of all.

Experimental Work.

Experiments for the prevention and control of the rot were conducted at both places. Tryon is in the western mountainous region of the State, and is situated in a warm little valley surrounded by mountains, which keep off the cold winds. In this place there are a number of comparatively small vineyards and fruit orchards. The experiments were conducted in the vineyard of Mr. R. F. W. Allston. The Niagara was the main variety grown here, but there were also small blocks of Delawares, Catawbas, Lindleys and Brightons. The rot had been especially destructive the two preceding seasons. The vineyard was plainly badly infected, the old rotten bunches visible everywhere lying on the ground and hanging to the vines. Two blocks, each surrounded by untreated vines, were reserved for the experimental work here.

Southern Pines, the other station, is in the central part of the State, in the long-leaf pine belt. The vineyards here are much larger than at Tryon, some of them frequently sending out a car load of grapes a day to the larger Northern cities. The experiments were carried on in the vineyard of Dr. B. von Herff. Only two varieties were grown, the Niagara at one end and the Delawares at the other. The rot had been so destructive in the Niagara section that cultivation had been given up. The vines were merely cut back, leaving the old tops on the trellises with the shrivelled, rotten berries clinging to them. In the very middle, surrounded on all sides by these neglected vines, a block of 800 vines were pruned and cultivated as usual to be used for the spraying experiments.

On right Grapes from Sprayed Row, 6-4-50 formula. In the middle Grapes from Sprayed Row, 12-8-60 formula. On left, Grapes from Unsprayed Row. Good Grapes at back. Poor Grapes in front.

Experiments in Spraying Niagaras.

PLAN OF PLOTS AND TREATMENT.

The spray treatments were the main experiments of the season. There were four plots of these, all exactly alike. Each plot contained eight rows of about twenty vines each. Each row received a somewhat different treatment, as indicated below. At the end of each plot a solid block of a quarter to half an acre (depending on length of rows and shape of vineyard), was sprayed through the season with normal (6-4-50) Bordeaux mixture, in order to have spraying on a large scale for further observation.

Plots *a* and *b* were at Tryon in the Allston vineyard. Plot *a* was at the top of one of the hill sides on which the vineyard was situated, and at nearly the highest point. Most of the vines were of uniform size and in as good condition as any in the vineyard. The vines in this vineyard were not in a very vigorous condition. Plot *b* was in another part of the vineyard and situated at the foot of one of the hillsides at nearly the lowest point. The vines in this were not so uniform, many of them being in very poor condition, and setting very little fruit. It is not fair to include these rows in the general result, so rows 3, 4 and 5 were left out in the general averaging up. Row 2 was considerably better than the other rows.

Plots *c* and *d* were situated side by side in the von Herff vineyard at Southern Pines. The vines were trained after the Munson system, and were particularly uniform and well grown.

The plan and treatment of all the four plots was as follows:

Row 1, unsprayed.

Row 2, Bordeaux 6-4-50 formula, all sprayings.

Row 3, Bordeaux 12-8-50 formula, all sprayings.

Row 4, first two sprayings omitted, second two Bordeaux 6-4-50 formula, last two 1 per cent copper sulphate solution.

Row 5, Bordeaux 6-4-50 formula, and bunches bagged.

Row 6, Bordeaux first sprayings, Bordeaux Lysol last three sprayings.

Row 7, Bordeaux 6-4-50 formula, first four sprayings; ammoniacal copper carbonate (*b*) last two sprayings.

Row 8, Bordeaux 6-4-50 formula first three sprayings, Lysol solution last sprayings.

Applications.

Six applications were made in all. At Tryon the first application copper sulphate solution, six pounds to the barrel, was made March 31, while the vines were still in a dormant condition. The second application was made May 10-11, immediately before the blossoms

a. United States Department of Agriculture, Farmers' Bulletin, No. 38, p. 5.
b. United States Department of Agriculture, Farmers' Bulletin, No. 38, p 8.

opened. This should have been made at least a week earlier, but delay in getting the apparatus in working order prevented. The first wave of black rot appeared only two days later. The third spraying was May 19-20, after the blossoming time was over; the fourth on June 3-4; the fifth, June 19-20; the sixth and last, June 28-30. The same applications were made on corresponding dates at Southern Pines. The dates of the applications and the materials used on each row at each date are here given in tabular form. All spraying at both places was under the direct personal supervision of the writer.

TABLE I.

Showing Applications Given Each Row on Each of the Six Dates.

Plots *a* and *b* at Tryon.

	March 31	May 10-11	May 19-20	June 2-3	June 19-20	June 28-30
1. Unsprayed						
2. Bordeaux 6-4-50 formula	CuSO4	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
3. Bordeaux 12-8-50 formula	CuSO4	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50
4 Two omitted, two Bordeaux, two CuSO4			6-4-50	6-4-50	1 per ct. CuSO4	1 per ct. CuSO4
5. Bagged	CuSO4	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
6. Bordeaux-Lysol	CuSO4	6-4-50	6-4-50	½ per ct. Lysol. 6-4-50	¼ per ct. Lysol 6-4-50	⅛ pr. ct Lysol, 6-4-50
7. Bordeaux, last two Ammoniacal	CuSO4	6-4-50	6-4-50	6-4-50	Ammoniacal	Ammoniacal
8. Lysol	CuSO4	6-4-50	6-4-50	1 per ct. Lysol.	1 per ct. Lysol.	

Plots *c* and *d* at Southern Pines.

	April 4	April 28	May 23	May 30	June 13-14	July 3
1. Check						
2. Bordeaux, 6-4-50 formula	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
3. Bordeaux, 12-8-50 formula	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50
4. Two omitted, two Bordeaux, two CuSO4			6-4-50	6-4-50	1 per ct. CuSO4	1 per ct CuSO4
5. Bagged	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
6. Bordeaux-Lysol	6-4-50	6-4-50	6-4-50	½ per ct. Lysol 6-4-50	¼ per ct. Lysol 6-4-50	⅛ pr. ct Lysol 6-4-50
7. Four Bordeaux, last two Ammoniacal	6-4-50	6-4-50	6-4-50	6-4-50	Ammoniacal	Ammoniacal
8. Lysol	6-4-50	6-4-50	6-4-50	1 per ct. Lysol	1 per ct. Lysol	

At both places a barrel sprayer conveniently mounted on two wheels was used. At Tryon, one man did the pumping and another handled the nozzles, the spray cart going up one side of the row and coming back on the other. This insured all the rows and both sides of each row being sprayed very nearly alike. At Southern Pines the vines were larger and trained in the Munson system, and after the vines were fully branched out, one man standing on the ground could not spray the broad spreading tops of the vines. In the last three sprayings, therefore, one man walked on the ground and sprayed the under side, while another rode on the cart and sprayed the upper side of the vines. Both sides of each row were sprayed in the same way. At Tryon, the vines being smaller and trained in the Kniffen four-arm system, this extra man was not needed. In all cases Vermorel nozzles with very fine caps were used.

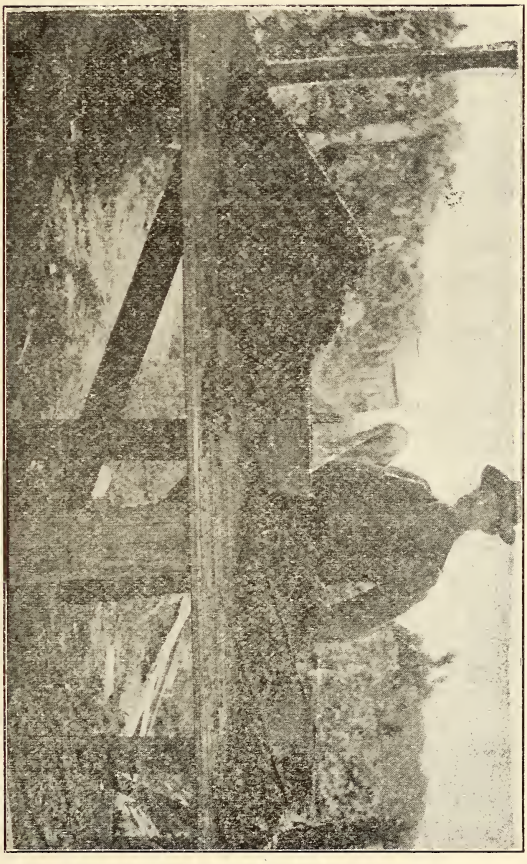
For the first application before the leaves appeared, single Vermorel nozzles were used. At the second and third sprayings, double nozzles were used. For the others, extensions carrying three nozzles were used. At the fourth application, a double nozzle was used in the middle, and single ones at each end, making four nozzles in all. At the fifth and sixth sprayings, three double nozzles were used. By means of this extension carrying three nozzles, a broad sweep of fine spray was obtained, which covered the vines quite rapidly and thoroughly.

The Results of Spraying.

At Southern Pines, in my absence, the grapes from the experimental plots, owing to an unfortunate mistake, were picked the first time without being weighed or measured. The second picking was weighed, and the weights from each row are given below. There was probably not so great a difference as the figures of this second picking would indicate, since the rows yielding the most did not mature their fruit as early as those with a smaller yield. In these plots there were twenty vines in each row, and all the vines were uniform.

Weight of Grapes at Second Picking.

	Plot *c*.	Plot *d*.	Average.
Row 1, Unsprayed	7	17	12
Row 2, Bordeaux 6-4-50	55	48½	51¾
Row 3, Bordeaux 12-8-50	52	54½	53¼
Row 4, Two omitted, two Bordeaux, two Ammoniacal	53½	70	61¾
Row 5, Bagged	122	104½	113¼
Row 6, Bordeaux-Lysol	57½	77½	67½
Row 7, Four Bordeaux, two Ammoniacal	54½	82	68¼
Row 8, Three Bordeaux, two Lysol	66	46	55



Grapes from sprayed row on left. Grapes from unsprayed row on right.

The grapes from the plots at Tryon were picked August 8-15. The bunches from each separate vine in each row were picked, counted, weighed, trimmed and weighed again. The averages of the numbers and amounts obtained in each row are given in Table III. In nearly every row there were some vines that set only a few bunches, or even none at all. These were noted and omitted in computing the averages for the row.

TABLE III.

Showing Yields of Rows in Plots *a* and *b*.

	Number of Vines in Row.	Number of Vines Taken.	Total Number of Bunches.	Average Number to Vine.	Total Weight Picked.	Total Weight Good.	Total Waste.	Average Weight Good.	Average Waste.
					lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
1—a	19	17	385	22.6	22— 6	14— 6	8— 0	0 13.5	0—7.5
2—a	18	17	402	23.6	78— 9	77— 0	1— 9	4 - 8.0	0—1.5
3—a	18	17	435	25.6	82—11	80—14	1—13	4—12.0	0—1.7
4—a	18	13	266	10.5	45—11	42—11	3— 0	3— 5.0	0—3.7
5—a	19	13	288	22.2	52—15	49—13	3— 2	3—13.0	0—3.8
6—a	21	16	385	24.1	75— 2	72— 8	2—10	4— 8.5	0—2.6
7—a	22	17	392	23.0	74—13	73— 0	1—13	4— 5.0	0—1.7
8—a	25	13	230	17.7	35—15	33—12	2— 2	2— 9.5	0—2.6
1—b	19	15	332	22.1	25— 0	20— 3	4—13	1— 5.5	0—4.8
2—b	19	16	435	27.2	69—11	67—11	2— 0	4— 3.7	0—2.0
3—b	20	20	357	17.8	59— 6	57— 7	1—15	2—14.0	0—1.9
4—b	20	20	345	17.3	40— 2	37— 6	2—12	1—13.9	0—2.2
5—b	19	10	168	16.8	29— 7	28— 7	1— 0	2—13.5	0—1.6
6—b	21	19	367	19.3	61—12	60— 6	1— 6	3— 2.8	0—1.2
7—b	20	15	283	18.8	46— 8	45— 3	1— 5	3— 0	0—1.1
8—b	20	20	415	21.0	53—13	49— 5	4— 8	2— 7.4	0—3.6

In Table IV, the results in plots *a* and *b* are averaged and summarized. In making up this summary, rows 3-b, 4-b and 5-b were omitted, as all the vines in those rows were much below the average in vigor and productiveness.

TABLE IV.

Summarizing Results of Different Treatments.

	Number of Vines.	Average Number of Bunches.	Average Weight. Good.	Average Weight Waste.
			lb. oz.	lb. oz.
1. Unsprayed	32	22.3	1— 1.5	0 - 6.1
2. Bordeaux 6-4-50	33	25.4	4— 5.8	0—1.7
3. Bordeaux 12-8-50	17	21.7	4—12.0	0—1.7
4. Two omitted, two Bordeaux, two $CuSO_4$	13	10.5	3— 5.0	0—3.7
5. Bagged	13	19.5	3—13.0	0—3.8
6. Bordeaux-Lysol	35	21.7	3—13.6	0—1.9
7. Bordeaux; last two Ammoniacal	32	20.9	3—10.5	0—1.4
8. Lysol	33	19.3	2— 8.4	0—2.7

As seen above, the average weight of good grapes obtained from a vine in the unsprayed rows was 1 pound 1.5 ounces, as compared to 4 pounds 5.8 ounces from those given six sprayings with normal Bordeaux mixture, a difference of 4 pounds 4.3 ounces to the vine, or over a ton to the acre. This gain of a ton or more of grapes to the acre was due entirely to the six sprayings, at a cost of about $15.42. In addition to this increased yield, the grapes could be picked at less cost, the trimming could be almost done away with, and in the end a product of far better quality commanding a higher price was obtained.

The yield from the rows sprayed with the double strength Bordeaux (12-8-50 formula) was very little more than the rows sprayed with the normal mixture.* However, the vines were healthier looking and there was less black rot on the leaves and berries, hence the stronger mixture must be considered the most effective. Ordinarily, the 6-4-50 formula is strong enough, but in a wet season or during spells of hot, wet, muggy weather, when black rot infection is more likely to take place, I should recommend the use of a stronger mixture, one containing 8 or 9 pounds of sulphate and the corresponding amount of lime to the barrel.

The first two sprayings were omitted from the fourth row; in consequence, the yield was not quite so high as in the neighboring row sprayed the six times. To avoid the stains made by Bordeaux, a 1 per cent solution of copper sulphate was used for the last two sprayings, and while this point was attained the foliage was otherwise injured to some extent. As there was no black rot after these sprayings were made, no evidence was obtained as to the effectiveness of this solution in preventing rot.

* United States Department of Agriculture, Farmers' Bulletin, No. 38, p. 5.

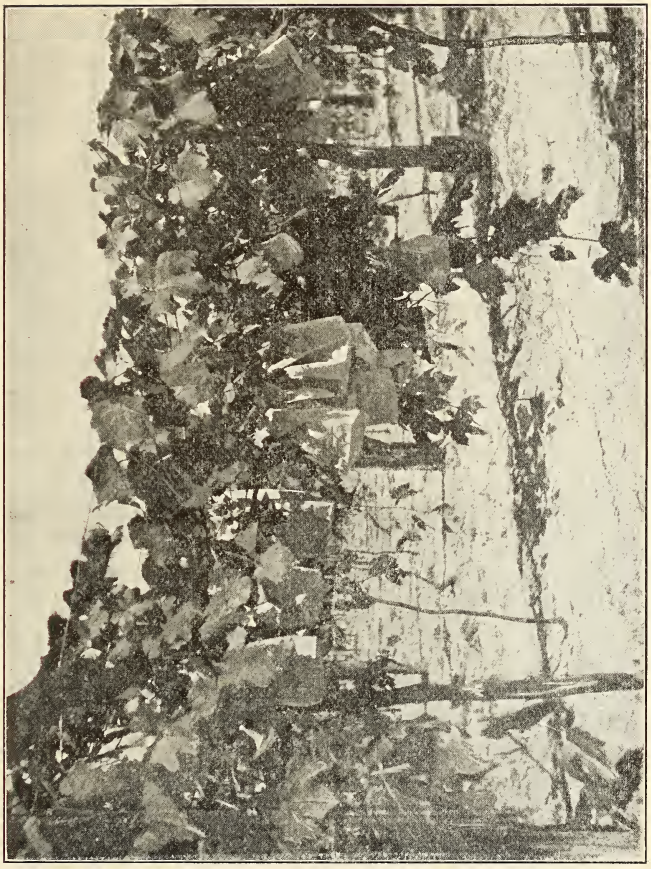
Bags were used in the fifth row. This method is discussed on page 144. The sixth row was sprayed with normal Bordeaux mixture. In the 4th, 5th and 6th sprayings $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{8}$ per cent respectively of lysol was added to the Bordeaux. This had the effect of making the spray spread over the berries better. That this row did not yield as much as rows 2 and 3 was due rather to the fewer bunches set than to the differences in spray treatments.

On the last two sprayings ammoniacal copper carbonate solution was used in the place of the Bordeaux mixture in order to avoid the Bordeaux stains. The solution was satisfactory in this respect and did not injure the foliage. Its effectiveness as compared with Bordeaux for the prevention of black rot was not learned since there were no attacks of black rot after these applications. The probability, however, is that this is the best solution to use for the last sprayings.

The eighth and last row was sprayed with Bordeaux at first and with lysol on the fourth and fifth sprayings. Lysol is an antiseptic prepared from cereosol, which was used and recommended several years ago by some French vineyardists as a protection against black rot and claimed to be more effective and satisfactory than Bordeaux for that purpose. A 1 per cent solution of lysol was used for the fourth spraying. When thoroughly agitated the preparation somewhat resembles soap-suds. The application was made in the afternoon, the day being bright and clear. A few days later some injury to the leaves was noticed. Accordingly, at the fifth spraying a solution of only $\frac{1}{2}$ per cent was used. This application was made on a cloudy morning immediately after the dew was off. The next day the leaves were found to be very badly damaged, probably because the stomata were more open in the cloudy weather. The injury was so great that at the time of the sixth spraying another row was used and a $\frac{1}{4}$ per cent solution applied, with no bad effects. Notwithstanding the two applications of lysol there was more rot on these two rows than on any of the other rows receiving treatment, while in addition to injuring the leaves the lysol specked the berries, very much injuring their appearance. From all this it appears that lysol can not safely be used and does not prevent the rot, even when used in strengths injurious to the vine. Also, it is more expensive than Bordeaux.

Spraying Other Varieties.

Besides the spraying on the Niagaras, small blocks of Delawares, Catawbas, Lindleys and Brightons were sprayed five times with normal Bordeaux mixture. No rot or other fungus disease was seen on these sprayed vines during the season. The greatest injury among the unsprayed vines of these varieties was caused by mildew, many vines being completely defoliated before the fruit had ripened.



Bagged bunches on vines at Southern Pines.

These four varieties were plainly much less susceptible to rot than the Niagaras. This suggests that some other large white varieties might perhaps be substituted for the Niagara.

Bagging the Bunches.

One row in each of the four plots was bagged for comparison with the spraying methods. Three-pound bags were fastened by means of pins or pieces of wire, over the bunches, just after they had set. In the bagged rows the average yield of good grapes to the vine was 3 pounds 13 ounces, or about 9 ounces less than that in the sprayed rows.

The bunches on both the sprayed and unsprayed rows were bagged at different dates, beginning when the grapes were in full bloom. When the grapes were picked no difference could be detected in favor of those sprayed before bagging. Bagging seemed to prevent further rot, even in bunches where it had already begun. Neither did the time of bagging make any difference after the grapes had fully set, but those bagged when in full bloom had small berries and imperfect bunches. It is recommended, however, that bagging be done as soon as possible after the bunches have set. The cost of bagging is somewhat more than spraying. The bags in quantity cost a little less than $1.00 a thousand, and an ordinary hand should put on one thousand bags a day. By using cheap labor at an average of 75 cents a day, the cost of one thousand bags put on the vines would be about $1.75, accordingly one may estimate the cost of bagging the best bunches on an acre of vines at about $18.00. The bagging can be done all at once in the early part of the season and does not have to be repeated at intervals. Very cheap labor can be used and do just as good work as better labor. The grapes when picked are cleaner and better looking than grapes that have suffered from exposure to the weather and insects. On the other hand, many of the smaller bunches that may be saved by spraying, it does not pay to bag, and it is impossible to bag some of the larger bunches, owing to their position on the trellises or among the vines, while some of the bags are blown off during storms. So after all, quite a proportion of the grapes remain unprotected by the bagging method. Bagging does not protect the leaves from rot, mildew and other fungus diseases, as is done by Bordeaux, but it is a fairly satisfactory method of protecting grapes from black rot and may be recommended to those who are unable to do good work in spraying. Spraying is the best and cheapest method, if it is done properly, as, in addition to protecting the grapes, it is of considerable value in keeping up the general health and vigor of the vines.

Bags torn away at end of season, showing the bunches free from rot. Bunches unbagged partly or entirely diseased.

Picking off Diseased Leaves and Berries.

At Tryon experiments were made in picking off diseased leaves and berries, both from sprayed and unsprayed rows. The unsprayed rows, being completely surrounded by infected and neglected vines, were constantly re-infected so that the diseased berries and leaves soon became too numerous to handle. This method might succeed in a vineyard nearly free from rot, but certainly could not succeed in a badly-infected vineyard. In the sprayed rows only a few pickings were required and these took but a short time. In all the rows picked the average number of diseased leaves to the vine was less than one in the sprayed rows and was over eleven in the unsprayed rows. The leaves from the sprayed rows generally had but one or two spots while those from the unsprayed rows were frequently covered with spots. Where spraying has been carefully done it is perfectly possible and seems desirable to pick off the few leaves and berries that may have been missed and become diseased, as each spot may become a source of infection to newly developed tissues or to parts not thoroughly sprayed. As each rotten berry must in any case be removed before the bunches are packed it is better to take it out when the bunch is still growing so that the empty space may be filled in by the other berries, thus making a more compact and finer looking bunch. It is better and cheaper and a finer product is obtained if this trimming is done as soon as the spots appear, than if one waits for greater damage to be done.

The Effect of Fertilizers.

It has been suggested that the use of fertilizers, especially of nitrogenous fertilizers, tended to make the grapes more liable to rot. At the Experimental Farm of the North Carolina Horticultural Society there are plots of grapes, peaches and other fruits receiving different fertilizer treatments. Capt. McNair, the superintendent, stated that in 1901 the amount of nitrogen used had a very marked effect upon the amount of brown rot occurring in the peach plots; the more nitrogen used, the more rot. In these plots under treatment a part of each row was fertilized and a part left unfertilized. I kept watch of these as well as the grape plots in the different fertilizer trials, but there was not enough rot in either place to permit one to arrive at any definite conclusions in regard to grapes. However, I noticed that in some places where grapes were in poor soil and poorly fed the vines were less vigorous and much more susceptible to rot. It would therefore seem that the vine should have enough of the different fertilizer elements to keep it in a healthy, thrifty condition. It is possible that more nitrogen than is actually needed by plants may make grapes as well as peaches liable to rot.

Average sprayed bunches from sprayed plots at Tryon, 6-4-50 formula.

Keeping the Vineyard Clean.

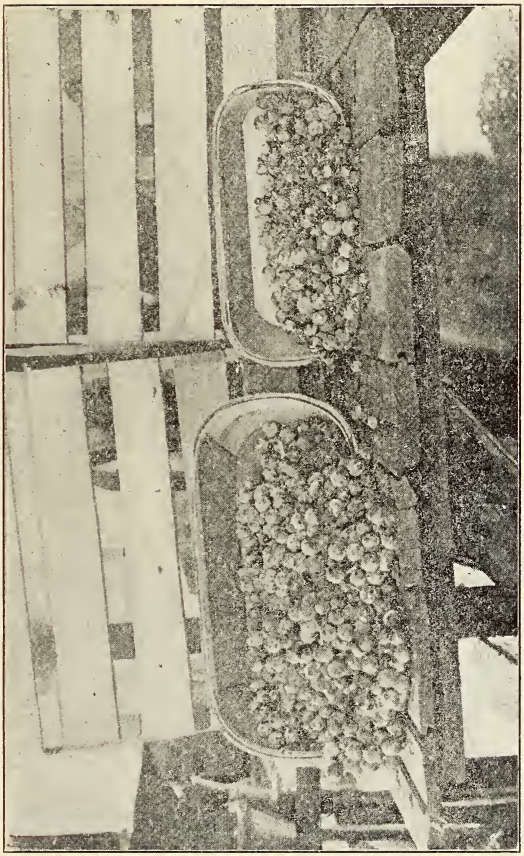
No experiments were made in this line, but a number of different vineyards were under observation. In those vineyards where all of the old dead leaves and rotten grapes had been carefully cleared away and the prunings burned the previous fall, there was very little rot after the spraying of the following season. My own experiments in spraying Niagaras in the midst of badly infected vines show that, at least in an ordinarily good season, it is possible to almost entirely prevent rot by spraying alone. In most cases, however, among the Niagaras where the vineyard was not cleaned there was more or less rot. In those Niagara vineyards that were neither cleaned nor sprayed, the rot was generally quite destructive.

Bordeaux is not a cure, but a preventive. In a good season, and perhaps in any season, thorough spraying would be sufficient without the cleaning up. It is during critical periods of bad weather that black rot gets a foothold and spreads and destroys the crop. If, at such a critical time, the Bordeaux has just been applied and covers every part of the vine, all may be well, but if not, infection may take place, more especially if there are diseased leaves and rotten grapes lying around on the ground and clinging to the vines. At such a time it would be advantageous to have the vineyard as clean as possible, especially where the Niagara is grown. Accordingly, it is recommended that all dead leaves and rotten grapes be raked up and removed, and rotten grapes clinging to the vines and trellises picked off. Loose, shredded bark that can be readily pulled from the vines, prunings, dead grass and weed should be burned; in fact, anything capable of harboring the dust-like spores should be destroyed or taken away. While the vines are still in a dormant condition, spray with the copper sulphate solution, thoroughly wetting the vines and posts, and paying particular attention to bunches of tendrils or rough surfaces on the posts that would be likely to retain the spores. Keep the whole surface of the ground cultivated in order to bury such spores as have lodged on the surface. Then spray. It is much easier to keep black rot out of a vineyard once cleaned, than to keep it down in a vineyard not cleaned.

Making Bordeaux Mixture*

Many of the failures in the use of Bordeaux mixture are due to the fact that it has not been properly made. Improperly made, Bordeaux mixture is likely to settle even before it can be applied, so that a part of the vines sprayed from the barrel do not receive their full amount of copper. Such Bordeaux does not stay on well. After paying for the materials and going to the trouble and expense of making the applications, vine growers, through ignorance or carelessness

* United States Department of Agriculture Farmers' Bulletin, No. 38, pp. 5-8.



Average yield from sprayed vine on left; average yield from unsprayed vine on right.

in preparing the Bordeaux, often lose the whole benefit of their spraying.

Bordeaux mixture consists of six pounds of copper sulphate and four pounds of lime in a barrel of water. The lime and the copper sulphate are generally kept in stock solutions of one pound to a gallon of water. In making this solution of the sulphate, it is only necessary to measure out the water in a clean barrel, and having weighed out the required amount of sulphate, tie it up in a square of cheese cloth and suspend near the surface of the water.

It is more difficult to get a good lime solution. The best quicklime should be obtained. After weighing, it should be placed in the bottom of a clean barrel and slacked there by pouring over it at first a small quantity of warm water until the slacking begins, then gradually adding more water as the process continues. When all the lime is thoroughly slacked, the water to the required amount can be added, and the whole thoroughly mixed by stirring. The lime solution should always be thoroughly stirred before any is taken out to make the Bordeaux.

In making up the Bordeaux mixture, the two stock solutions should never be poured together, but both should be considerably diluted before mixing. The lime should be strained through a strainer made of brass netting, having about twelve meshes to the inch. If one dilute solution is poured into the other, *it should be always the sulphate solution that is poured into the lime solution, never the reverse;* and the mixture meantime should be kept thoroughly agitated by stirring. This pouring should be rather slow, in order to give time for the chemical reactions while the two solutions are in a state of agitation.

In making up Bordeaux, the writer employed a method suggested by Mr. M. B. Waite, of the Department of Agriculture, and found it very satisfactory. A rough platform was built on a side hill, on which were the barrels containing the stock solutions of lime and sulphate, and two half barrels having short pieces of garden hose attached to the bottoms. To make the Bordeaux, a stock solution of four pounds of lime was put into one half barrel and the solution of six pounds of sulphate in the other, and both were filled up with water by means of a hose. The spray cart was then backed up at the lower side of the platform and the two dilute mixtures run out through the strainer into the pump barrel through the pieces of hose. By this means the lime and sulphate are diluted, are thoroughly mixed while being run into the barrel, and are not combined too rapidly to make a good mixture. Under these conditions a light flocculent precipitate is formed that will not settle readily. If the solutions are too concentrated when brought together, or are not sufficiently mixed, the precipitate is coarser and heavier, and is likely to settle within a few minutes, with the bad results already described.

Average bunches from unsprayed plots at Tryon.

Unless for very good reasons, the proportion of lime to sulphate given in the directions should be used. If less than four pounds of lime to six pounds of sulphate is used, the foliage is likely to be burned. The general tendency, however, is to use more lime. This is undesirable for three reasons. It is the lime particles that are likely to clog the nozzles, so the more lime used the more liable the nozzles are to clogging, if nozzles are used with holes as fine as they should be. Secondly, from general observations I have concluded that the more lime used, the more easily the mixture is washed off. Thirdly, it is the sulphate that is effective in killing the spores and preventing the black rot. The lime is added simply to counteract sufficiently the poisonous action of the sulphate, so that it will not also injure the grape foliage. The aim in making Bordeaux is to make the sulphate as destructive as possible to the fungus without also being injurious to the leaves of the plants. If more lime is added than is necessary for this purpose, the toxic action of the sulphate may be so far weakened that it will not kill all the fungus spores, and the rot may follow.

Ammoniacal Copper Carbonate Solution.*

To make this preparation, dilute three pints of ammonia with six pints of water. Use enough of the solution to dissolve five ounces of copper carbonate. The resulting solution, diluted with water, will make one barrel of spraying fluid. If they have previously been used for Bordeaux, the pump barrel and other receptacles should be cleaned before being used for the ammoniacal solution, since the lime deposited by the Bordeaux is likely to combine with the solution and form a precipitate that would stain the grapes.

The Application of Bordeaux Mixture.†

Wherever possible, a good barrel pump should be used. With this one man can do the pumping and a man on each side of the spray cart can spray thoroughly and rapidly the side of the row against which he walks. The spray is driven in against the foliage with considerable force, and is quite well distributed. With such an apparatus there is not so much temptation to slight the work in order to get over the ground more rapidly.

The part of the apparatus most generally at fault is the nozzles, which are almost without exception too coarse. None but the Vermorel type should be used, and these should have caps with holes not larger than a No. 2 needle. Such nozzles throw a fine, mist-like spray that is deposited in very fine particles that cover nearly or quite the whole surface of the leaves and berries. The coarser nozzles throw the spray in streams or fine drops that strike the leaves and roll off,

* United States Department of Agriculture Farmers' Bulletin, No. 38, p. 8.
† United States Department of Agriculture Farmers' Bulletin, No. 38, pp. 8-10.

Sprayed vine on left, unsprayed on right.

or collect, leaving the Bordeaux in blotches or spatters. The fine nozzles spread the mixture more uniformly, make it stay on better, and are more economical of material.

After the grape vines are in full leaf, an ordinary single or double Vermorel nozzle of the requisite fineness will not be sufficient to spray the vine well without stopping some little time at each vine. An extension carrying three nozzles will then be found to be a convenient and time-saving device. Such an extension rod can be made from 3-8 inch pipe by any plumber, at a cost of fifty or seventy-five cents Then either single or double Vermorels, as preferred, can be attached to this. Such a device gives a broad sweep of finely-divided spray that covers the vines rapidly and effectively. With a sufficient number of nozzles and a slow-going horse, the spray rig can be kept moving almost continuously and still do good work.

Every application should be thorough. The spray should be directed into the vine from both above and below, and from each side of the trellis, so far as possible to cover every leaf on both sides. Care should be taken to strike the woolly under surface of the leaves, as this is especially adapted to catch and retain the spores of the black rot fungus.

The first spraying should be with copper sulphate solution (6 lbs. of sulphate to a barrel of water), and applied while the vine is still dormant. Posts and wires as well as vines should be thoroughly treated. The second spraying should be made after the leaves and fruit buds have appeared, but before the flowers open. The third application should be made after the blossoming time, when the fruit has been set about ten days or two weeks. The other sprayings should follow at intervals of ten days until the first or middle of July. At the end of ten days so many new and tender leaves have developed, and the small berries have so increased in size, that it is dangerous to leave them unprotected for a longer time. After the vine is well grown, it is impossible, if the growth has been vigorous, to reach all the foliage with the spray. But if sprayed at intervals of ten days the whole vine will be reached from within outward as it develops.

Cost of Spraying.

At Southern Pines a careful account was kept each time of the number of vines sprayed with Bordeaux, the amount of mixture used, and the time required for the applications. These figures gave the estimate cost per acre of both material and labor. The Bordeaux costs almost exactly fifty cents a barrel The labor is estimated as the work of three men, each at $1.00 per day, one for the pumping and two to do the spraying; but in the majority of cases it would be sufficient for one man to spray, taking one side of a row at a time; this would considerably lessen the cost of labor. Probably, too, the

expense of experimental treatment on this small plot was proportionately more than for work on a larger scale.

The following table gives the cost of the material and labor per acre for each of the six sprayings:

	Amount Per Vine.	Cost of Material.	Cost of Labor.	Total Cost Per Acre.
1st	1½ gallon.	$0.45	$1.13	$1.58
2nd	1-8 gallon.	.68	1.13	1.81
3rd	1-7 gallon.	.68	1.10	1.88
4th	1-4 gallon.	1.36	1.47	2.83
5th	2-5 gallon.	2.06	1.65	3.71
6th	2-5 gallon.	2.06	1.65	3.71
Total		7.39	8.13	15.52

The seasons of 1900 and 1901 were unusually bad seasons in succession, and were very discouraging to the grape growers of North Carolina. The black rot made a nearly clean sweep, especially in the Niagara vineyards. Similar seasons can not, however, be expected to occur very often. At the close of the season of 1901, many growers had lost faith in the efficacy of Bordeaux as a preventive of black rot. But in the month of June there were rains nearly every day; there was scarcely time to get the Bordeaux on between rains, and not time enough for it to dry enough to stay on, even if the applications were made. At the same time conditions were extraordinarily favorable for the development of the black rot fungus. The previous bad season had stocked the vineyards well with the fungus. Under such conditions it was not strange that there was an unusual development of rot.

The season of 1902 has been a good one. These experiments, as well as the experience of many of the grape growers, have shown that in such a season, at least, grapes, even the susceptible Niagara, can be grown in North Carolina in spite of the black rot. And this, too, after the vineyards were badly infected by two seasons of black rot. In some cases good grapes from the less susceptible Delaware were grown without spraying. All this is encouraging. Not all the seasons are going to be bad seasons. I am confident that by clean cultivation and careful spraying any variety of American grapes can be grown in most years if not in all.

The treatment recommended can be summarized as follows:

1. Clean up all old leaves, rotten grapes and other rubbish in the vineyards. Cultivate the ground so as to cover such material as can not be cleaned up.

2. Keep the vines in healthy, vigorous condition by cultivation and by the application of such fertilizers as are needed.

3. Spray thoroughly at least six times during the season according to directions, using the 6-4-50 formula generally, but increasing the strength in hot, muggy or wet weather.

4. Be very careful in making the Bordeaux mixture.

5. Use finer nozzles.

6. Beside spraying, when practicable pick off diseased leaves and berries.

7. When black rot appears in the vineyard, do not, for the sake of cutting down the expenses, neglect the vines. That is just when the vineyard needs more care. Those who spray for the first time in badly infected vineyards, must be much more thorough in making the full number of applications, and in doing this work carefully, than would be necessary in vineyards nearly free from rot. Only by such careful and thorough work can the black rot be kept down.